TAMPEREEN TEKNILLINEN YLIOPISTO
TAMPERE UNIVERSITY OF TECHNOLOGY

KIRAN SARMA

EFFECTIVENESS OF REAL-TIME BUSINESS INTELLIGENCE ON ENTERPRISE PERFORMANCE MANAGEMENT: A SYSTEMATIC LITERATURE REVIEW

Master of Science thesis

Examiner: Professor Samuli Pekkola

Examiner and topic approved by the Faculty Council of the Faculty of Business and Built Environment

On January 4th ,2017

In Business, the idea of measuring what you are doing, picking the measurements that count like customer satisfaction and performance…you thrive on that."

- Bill Gates (Founder of Microsoft)

"There are only three measurements that tell you nearly everything you need to know about your organization's overall performance: employee engagement, customer satisfaction, and cash flow. It goes without saying that no company, small or large, can win over the long run without energized employees who believe in the mission and understand how to achieve it."

- Jack Welch (Former CEO of General Electric)

ABSTRACT

KIRAN SARMA: Effectiveness of real-time business intelligence on enterprise performance management
Tampere University of technology
Master of Science Thesis, 59 pages, 9 Appendix pages
May 2017
Master's Degree Programme in Industrial Engineering and Management
Major: International Sales and Sourcing
Examiner: Professor Samuli Pekkola

Keywords: real-time business intelligence, business intelligence, real-time analytics, literature review, enterprise performance management, corporate performance management, business performance management

The purpose of the systematic literature review is to better understand how a real-time business intelligence can enhance an enterprise performance management (EPM) solution. The various processes and methodologies of EPM along with its integration with real-time business intelligence is studied in this paper. Many studies focus on the role of real-time analytics in organizations, but there are very few that focus on the linkage between real-time business intelligence and enterprise performance management. This Master of Science thesis aims to address that gap. The review is conducted by comparing and synthesizing research studies done in this area. The findings prove that real-time business intelligence is beneficial enough to implement to monitor enterprise performance since faster and better decision making on business processes is enabled. With the emergence of artificial intelligence and machine learning algorithms, there is a bright scope for automated decision making and performing actions. This could help reduce the third and impeding latency type in business intelligence which is decision/action latency.

The literature review also suggests that there is more research needed linking real-time business intelligence and enterprise performance management. In conclusion, this review's findings have shown that real-time business intelligence when integrated with enterprise performance management solutions can help the business gain competitive advantage after careful consideration of the purpose and effects of implementation.

PREFACE

The journey of writing my master's thesis began with great enthusiasm for the topic being chosen. The knowledge gained during my internship with SAP in the field of performance management helped me with foundational knowledge. I have been able to learn and study more on this subject during the entire duration of this study. This entire process of writing my Master's thesis has helped me gain insights on how systematic literature reviews are conducted. It has not been an easy task to complete this thesis research without showcasing patience and perseverance.

I would like to thank Professor Samuli Pekkola from Tampere University of Technology for acting as a supervisor and examiner for my research. I am grateful for the continued consideration, patience and constructive feedback given throughout the writing of this thesis.

Finally, I would like to thank my family and friends for the support and all the advice given during this time. Without your moral support, this thesis completion would have been very difficult. Thank you very much.

Tampere, 15.05.2017

Kiran Sarma

TABLE OF CONTENTS

LIST OF FIGURES

TERMINOLOGY

AI	Artificial Intelligence
BI	Business Intelligence
BPM	Business Performance Management
CFO	Chief Financial Officer
CPM	Corporate Performance Management
CRM	Customer Relationship Management
DW	Data warehouse
EPM	Enterprise Performance Management
ERP	Enterprise Resource Planning
HANA	High-performance Analytic Appliance
HCM	Human Capital Management
IS	Information Systems
IT	Information Technology
PM	Performance Management
RTBI	Real-time business intelligence
SCM	Supply Chain Management

1. INTRODUCTION AND MOTIVATION

"Knowledge has become the key economic resource and the dominant, if not the only source of competitive advantage"- Peter F. Drucker

1.1 Background of the Research

Increased innovation and globalization has contributed to opportunities in the marketplace for organizations and customers (Ranjan, 2008). Business management across the globe has deeply changed and it is more driven towards metrics-driven management. Information Systems (IS) and Information Technology are essential for operations and management of organizations. Data and information are key resources for executing operational processes and transactions. Many companies make use of ERP (Enterprise resource planning) systems to manage company processes. Information systems collect a company's transaction data and that is stored in databases. From the databases, data is retrieved and processed to create reports and insights about the performance of the organization. Management Information Systems (MIS) help perform this entire process. Based on the collected data, business intelligence applications can provide more in-depth analysis on a company's performance. Performance is usually measured with KPIs (Key Performance Indicators) and data is fragmented between various systems making performance management reactive. Vendors have looked at this downside and have tried to defragment performance information leading to creation of EPM (Enterprise Performance Management) applications.

Massive amounts of information is gathered by organizations and senior management and more often than not wonder if they are making maximum use of the information to derive meaningful insights. New technologies help in collecting data from different sources and still organizations are looking for better ways to generate more value to stay competitive and succeed. The dominant era of Information Technology (IT) has drastically changed the end-user computing environment over the past decade. Management decisions have been enhanced and enabled by significant investments in business intelligence (BI) systems.(Hou, 2012)

As (Mikroyannidis & Theodoulidis, 2010) explain that a BI system is a "collection of techniques and tools aimed at providing businesses with the necessary support for decision making"(p.559). Therefore, BI systems are capable of providing real-time information, create rich and targeted analytics, monitor and manage business processes through dashboards for displaying key performance indicators (KPI) together with current and historical data relative to organizational targets (Hou, 2012). Information

Technology is ubiquitous and is forming a critical part for a modern organization helping drive operations and being part of critical decision making processes. Organizations have started to increasingly use analytics for a range of purposes across different industries. From the dimensions of consuming data, analyzing data and reporting data, BI has paved the way for real-time BI wherein the period of time between the occurrence of an event that requires an appropriate action by the organization and the time the action is carried out (Seufert & Schiefer, 2005). According to (Hackathorn, 2002), business value of an action decreases, the more time elapses from the occurrence of the event to taking action. The process of analyzing data to foresee market trends and to improve performance of enterprises has always been playing a role in a competitive business. However, business analysis is usually done in a monthly or yearly pattern or sometimes bought from research companies that specialize in this area. For an organization to excel it is a must to have an agreed specific business strategy. This has been widely accepted by business specialists, business economists, and psychologists. Apart from having a specific strategy set, businesses must also possess an effective performance measurement system that matches every aspect of the business - from the boardroom to the factory floor - to the strategy. The recent interest in data analytics capabilities has given rise to many companies opting for software that can fulfill their needs.

The need to conduct this study was to examine the role of real-time analytics and its role in enterprise performance management. EPM is a process to maintain business performance by linking strategies to plans and execution. The role of business intelligence in EPM has been very important. The analytics provided from a BI system helps performance management managers make key decisions. Initially, EPM used to focus on the financial aspect of an organization like providing financial statements, releasing actual vs. plan reports etc. This was enabled due to the BI system in place. Now, EPM is an enterprise wide term, denoting performance management across all areas of an organization. The less interesting feature about using a conventional BI system was that it lacked real-time data. This meant, managers made key decisions based on data that was days, weeks old. Thus, the decisions made were not always applicable after the specific time period. This is where real-time analytics enabled by real-time business intelligence tools positioned itself in EPM. Real-time analytics enables organizations to do the same procedure but in real-time gaining real-time insights. The challenge is exploring this processed data at its maximum granularity and discovering ways to leverage this information in real-time. The demands from an analytics solution keeps mounting as the needs of the organization grows.

1.2 Problem Description

The purpose of this Systematic Literature Review (SLR) is to provide a linkage that studies the impact of a real-time business intelligence solution on enterprise

performance management. Business intelligence solutions are incorporated in businesses to positively influence decision making capabilities and for measuring performance. When business intelligence can be realized in real-time with today's advanced technologies, the need to assess the influence of it on enterprise performance management capability arises. An enterprise performance management solution provides capabilities to a company to plan for suitable processes, people and technology. It is interesting to find out how by possessing latest and up-to-date data, business can plan for resources, execute business decisions and produce impactful reporting.

1.3 Motivation

An enterprise performance management software solution touches many areas of a business. This includes planning, budgeting, forecasting, consolidation and reporting. In earlier times, due to the unavailability of current real-time data, activities such as planning, budgeting and forecasting used to be based on historical data stored in databases. However, due to advancement in the field of business intelligence, the availability of real-time data has been made possible. Now businesses can plan and forecast based on the latest happenings related to one's business. It is fascinating to assess the impact of real-time business intelligence solutions on enterprise performance management and also find the factors influencing the decision to deploy a real-time BI powered EPM solution.

The focus of this systematic literature review thesis is to study the effectiveness of real-time business intelligence solutions on performance management of an enterprise. Organizations currently face challenges such as varying priorities, variety of data and its enormous growth, and financial constraints in implementing software solutions. In addition, there are challenges such as customer privacy and encryption that form a part of regulatory provisions an organization has to fulfil. The larger question becomes "how to leverage real-time analytics while still meeting regulatory requirements." Businesses are having to make key business decisions in real-time that attracts enormous pressure on leaders, managers and other key decision makers to develop real-time analytics applications to process data from varied sources, apply advanced analytics and finally, present suggestions and recommendations in real-time.

Online analytical processing, data warehousing, business intelligence, enterprise performance management concepts have been around for many years; but, the requirement for effective implementation of performance management solutions in an enterprise has just started to be accomplished. Many new strategies are being developed, tested and employed on a regular basis as performance management solutions is still in the elementary stage. In order to make an EPM implementation beneficial, it is useful to have an evaluation completed on the project economic wise before a deal is struck. By studying the effectiveness of real-time business intelligence on EPM, the risk for

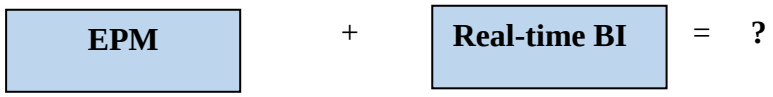
businesses deploying this software in the future could reduce. There are many questions that are to be answered before implementing a project such as whether to build or buy, technology to choose, vendor preference, estimation of ROI (Return on investment), need for consulting services. The research findings is an attempt to assist and inform the effectiveness of a real-time business intelligence solution on enterprise performance.

1.4 Research Question

There has been numerous studies about performance management influenced by business process management and business intelligence. However, there has been little research concerning the effectiveness of real-time business intelligence on enterprise performance management. In order to provide a better understanding of the effectiveness of a real-time business intelligence solution for better enterprise performance, this topic is chosen for the thesis.

The research question that will be addressed in this systematic literature review thesis is the following:

> *What is the effectiveness of real-time business intelligence on enterprise performance management? How does real-time BI work together with EPM?*



The motive behind the research is to understand the bigger picture of the effectiveness and impact, a real-time business intelligence system can create on enterprise performance management. The real challenge for companies has been on how to leverage information both internal and external and extract the maximum possible value and insights. Enterprise performance management driven by traditional BI tools have been fed with older data enabling decisions that may not be valid or useful in that moment of time. The call for turning an EPM solution into a decision making real-time system to impact business performance has given rise to this research question. The study focusses on the usefulness of real-time information on supporting improved business performance.

1.4.1 Question Structure

The research question is seen from the following viewpoints:

Populations	Peer reviewed articles describing effectiveness of real-time intelligence on enterprise performance management.

Interventions	Real-time business intelligence *vs.* Business intelligence on the performance of an enterprise.
Outcomes	Integration of real-time BI with EPM
Study Design	Primary studies including case studies, experiments, journals, surveys etc.

1.5 Theme and Scope

The theme of this study consists of real-time business intelligence, enterprise performance management, decision making, and reporting. The focus of this study would be on enterprise performance management enabled by real-time information, to support decision making and reporting capabilities. The central view point would be on EPM powered by real-time BI. Figure 1 below illustrates the theme of the study.

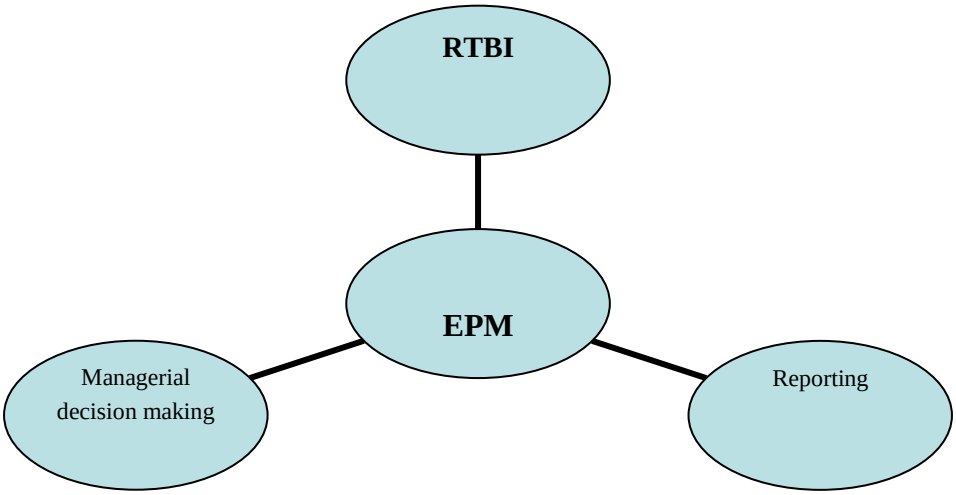


Figure 1. Theme of study.

This review will concentrate on EPM enabled by real-time BI and how that would enhance managerial decision making and reporting capabilities. Enterprise performance management on a general perspective is followed, and not towards any particular industry or functional area. The overall benefits of having real-time data for enterprise planning is highlighted in this study. The technical implementation and architecture of a business intelligence solution or an enterprise performance management solution is out of scope and will not be covered in this study. There is no comparison or bias towards any particular software vendor in this case study.

2. REAL-TIME BI AND EPM

2.1 What is Business Intelligence?

Business intelligence (BI) is a complex term and has been defined in many different ways. Some think it is limited to just data reporting and data visualization. There are others who think it helps in business performance management, data extraction, transformation and integration, and statistical analysis and data mining. This proves Business intelligence contains many facets. It is about capturing, accessing, understanding, analyzing raw data to turn it to actionable information to improve business performance. (Azvine, Cui, & Nauck, 2005)

To convert or transfer raw data into actionable information, three different types of technologies are used namely: 1) data warehouses (DWH), 2) analytical tools and 3) reporting tools (Watson 2009). Business Intelligence is identified as an important management tool that provides key decision making support (Negash and Gray 2008). It is essential to have a system in place that can predict market trends of products and services which in turn can help improve the performance of an enterprise. A trait of the BI systems, however, is the freshness of data that is made available to make reports (Watson et al. 2006). With heavy competition with every passing day, customers' needs keep changing and are more demanding, there is a need for enterprise decision makers to have fresh data to make reports from. They are no longer satisfied with schedules monthly or yearly reports with fixed dashboards and already set key metrics to measure performance. The demand for queries to be answered in a fast manner using actionable information from analytical applications have increased. The right information relating to real-time business performance data are expected to be present to the right people at the right time. The traditional BI tools that have been available are ill-equipped to solve the issues of providing timely insights for big data at such a high velocity (Geerdink 2013). For operational decisions such BI tools impedes organizations (Watson and Wixom 2007). To overcome the challenges of not having fresh data, real-time business intelligence, an approach to assure data freshness was designed (Chaudhuri et al. 2011). Thanks to the advances in technology, having real-time information on business processes has become feasible. It has become easy to retrieve all sorts of data and store them cheaply. Delivering insights about business processes in real-time to enable decision making has been made possible by Business intelligence (Azvine et al., 2005). Figure 2 below illustrates how raw data is converted to actionable insights through business intelligence.

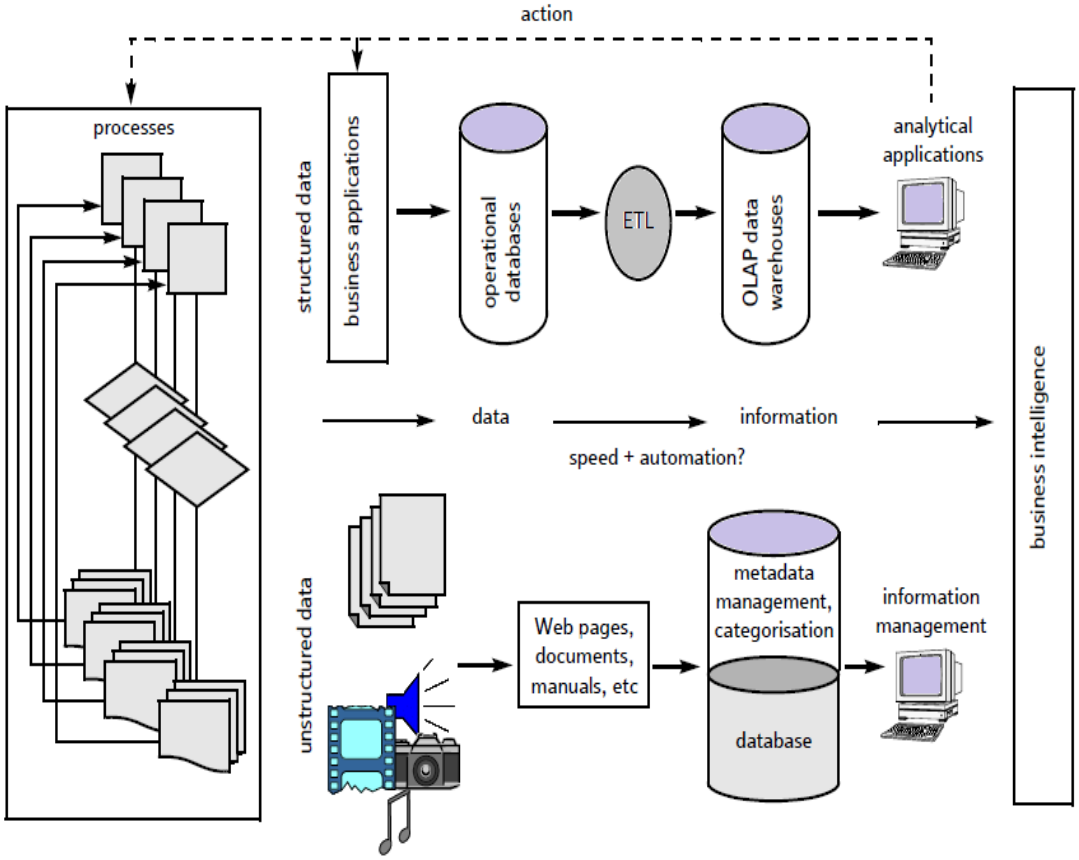


Figure 2. Business Intelligence process (Azvine et al., 2005).

The couple of critical technologies used by organizations selling software are Data warehousing and online analytic processing (OLAP) in many businesses or industries such as retail sales, telecommunications, and financial services for developing EPM systems (Mundy, 2002). Data warehouses collect data from different data sources both structured and unstructured texts and the analysis tools, thereafter, analyze the data to bring about meaningful insights. Without having to affect the operational systems, data warehousing solutions provide consistent, reliable and accessible data for decision making (Tvrdikova, 2007). Integration of different data sources and direction in the operations of an organization together with details of the operating environment is deduced (Inmon et al., 1997). Online analytical processing, on the other hand, is a technique to perform complex analysis of stored information in the data warehouse to provide decision support and status reports (Chaudhuri and Dayal, 1997). According to (Thomsen, 1997) OLAP is a category of applications and technologies for collecting, managing, processing and presenting multi-dimensional data for analysis and management purposes. Visualization and reporting tools producing information suited for information consumers and business users for decision making.

The current business management systems as illustrated by Azvine et al., (2005)**,** is shown below in Figure 3. As seen in the figure, there is constant intervention by a human between the strategic, tactical and operational layers. RTBI will need to align

strategic objectives (as shown in Figure 6) with business operations to reduce friction between the layers.

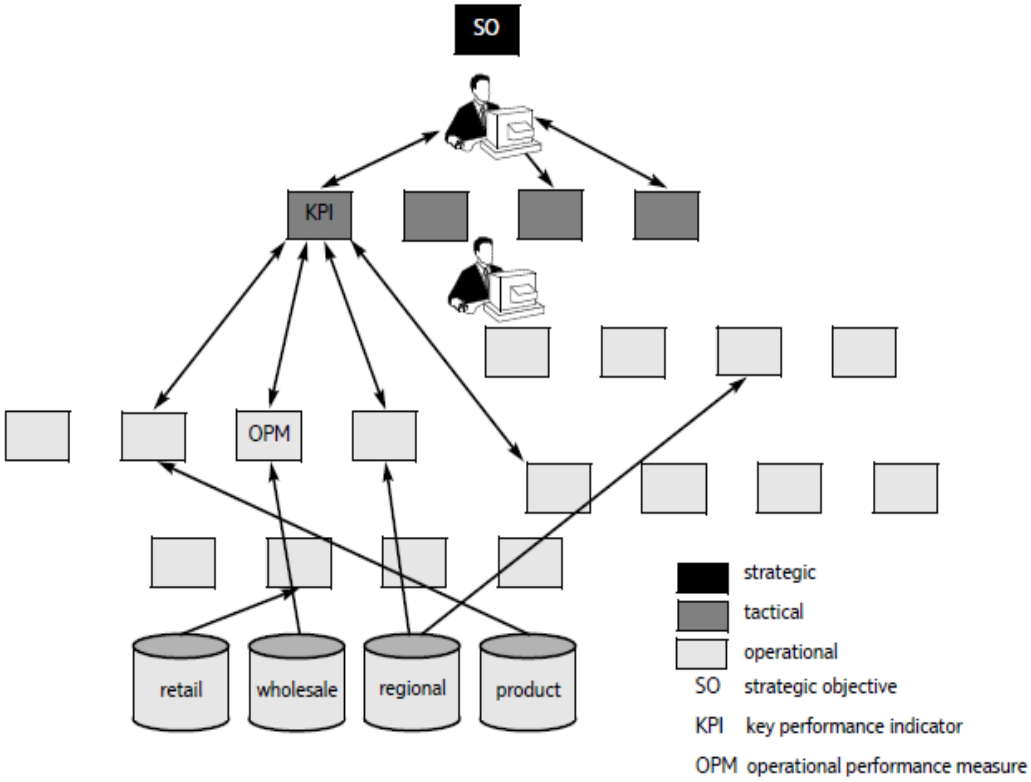


Figure 3. Current business management systems (Adapted from Azvine et al., 2005).

Figure 4 below shows the time-value curve in a decision making system. In the words of Dr. Richard Hackathorn, the founder of Time-Value Curve, "the value of data is directly proportional to how fast a business responds to it. A company loses monetarily as and when the information that has to reach decision makers is delayed." The time difference between the occurrence of a business event and an action taken in response to it is called latency. There exists three kinds of latencies namely: 1) data, 2) analysis and 3) decision latency. Data latency is the time taken to gather data from source and transactional systems and load it into the data warehouse for analysis. Analysis latency is the time taken to get access to the stored data and perform analysis. In this stage the data is transformed into valuable information and suitable business rules are applied. The final latency is the decision latency which is the time taken to make a decision and commit an action in response to the analyzed information. The figure below shows how with the passage of time the business value decreases. This is how traditional business intelligence systems operated. There was considerable latency issues with every step which accounted for a loss of value in the end. Action distance or action time is the time taken from the occurrence of the business event until the action is taken in response

(Popeangă, 2012). The lesser the action time, the more is the business value added to the company (Hackathorn, 2004).

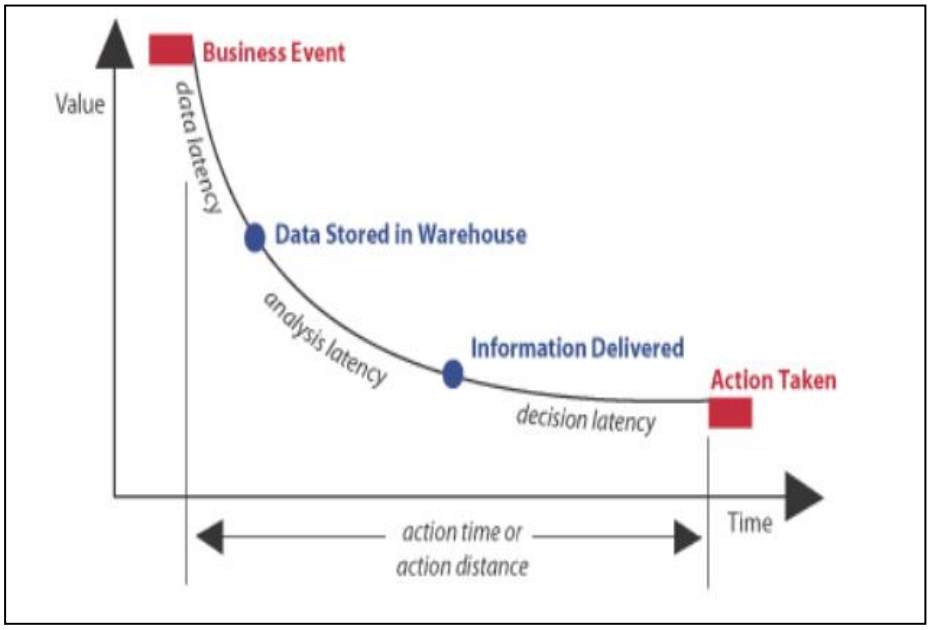


Figure 4. Time-value curve in decision making process (Adapted from Popeangă, 2012).

In order to gain competitive advantage for companies, the need to reduce the time spent to respond to business operations is significant (Sahay & Ranjan, 2008). That aspect gives rise to the following section real-time business intelligence where the intent is to reduce the issues of latency that occurs with traditional BI solutions.

2.2 What is Real-Time Business Intelligence?

RTBI solutions were built upon based on the architecture of traditional BI solutions (Watson 2009). Similar to Business intelligence, there is no fixed definition for real-time business intelligence. In the previous section, an overview of business intelligence was projected. Real-time can mean: data in real-time having zero latency, a process having access to information in real-time, a process providing information whenever required, deriving key measures reflecting performance at the current time (Azvine et al., 2005). According to Hackathorn (2003), the main characteristics of RTBI are minimizing the latencies of accessing data and execution of resulting actions - a time span that is referred to as action distance. In order to convert a traditional BI system to a real-time business intelligence system, components of data warehousing environment that are responsible for latencies have to be identified and managed to reduce them (McKenna 2011). The freshness of data does not have to be real-time for all businesses. Every business defines what an acceptable latency to them would be. Therefore, terms like near real-time (Eckerson 2004), right-time (Watson et al. 2006), or just-in-time

(Chaudhuri et al. 2011) are more exact, but since real-time is a phrase is used in academic literature, this term will be used in this thesis review. Figure 5 below shows the time-value curve as shows in Figure 4 but for a real-time business intelligence system. This denotes the relationship between time and value of a business event. At the start, a business event occurs and the event requires an action to be taken in response. As seen in the figure below, in a real-time intelligence system, data from the transactional source systems are readily made available in real-time for decision making purposes. The latency and action time can be drastically reduced, thus increasing the overall business value (Davis, 2006).

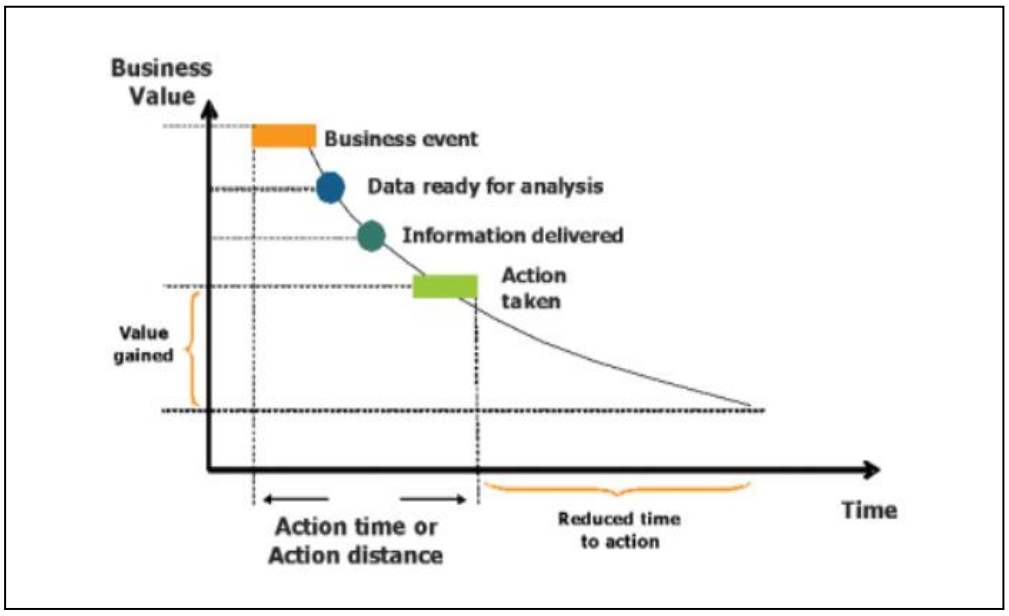


Figure 5. Time-value curve in RTBI system (Adapted from Popeangă, 2012).

RTBI follows the same functionalities as traditional business intelligence, but differs in the aspect that it extracts data from operational data sources with zero latency. According to (Azvine et al., 2005), RTBI could mean the following:

- Real-time delivery of information
- Real-time data modelling
- Real-time data analysis
- Real-time action based on insights

With technologies enabling RTBI, the flow of information from operational to tactical to strategic layers and then translating strategic objectives into operational drivers so that strategic decisions are made in real time. By moving from BI to RTBI, users can now drive processes and business managers can alter parameters of processes in real-time.

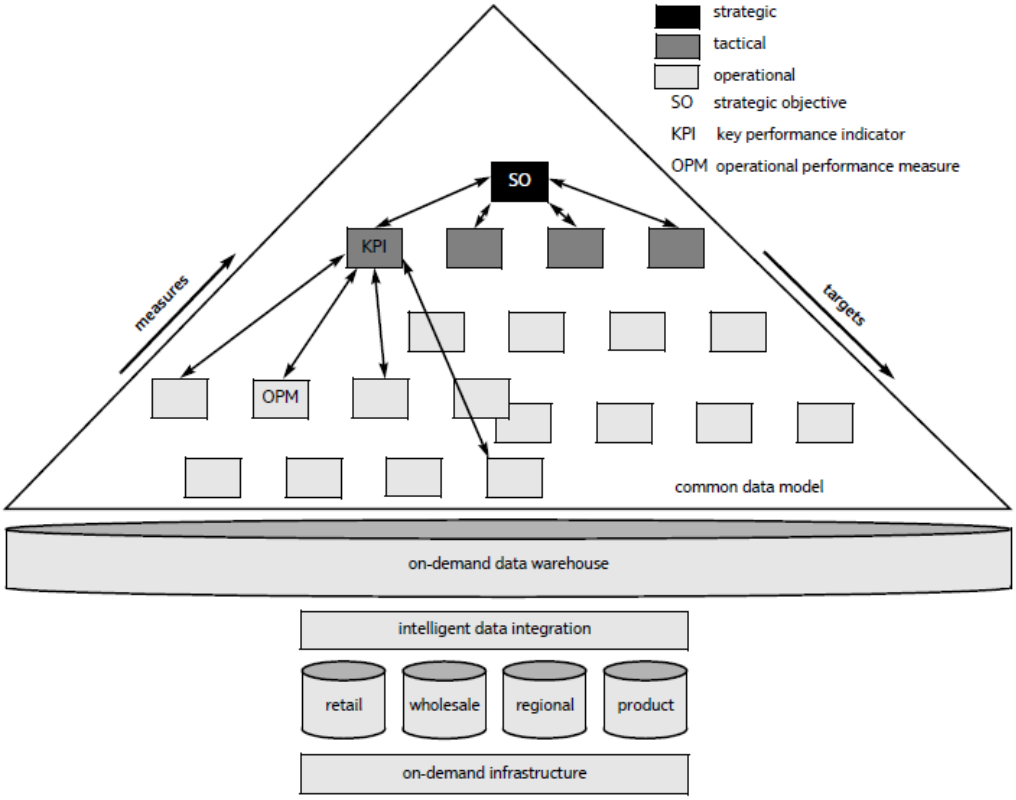


Figure 6. Goal of RTBI (Adapted from Azvine et al., 2005).

Addressing the need for real-time decision support, different concepts such as active warehousing, real-time analytics (Brobst and Ballinger, 2000; Raden, 2003) and real-time warehousing have become topics of interest in the business intelligence communities (Sahay & Ranjan, 2008). The primary objective of RTBI is to combine analytics with management functions to enable managers and other employee teams make real-time decisions.

2.3 Enterprise Performance Management (EPM)

2.3.1 What is EPM?

EPM (Enterprise Performance Management) that is also labelled as Corporate Performance Management (CPM) or Business Performance Management (BPM) or sometimes specifically Financial Performance Management (FPM), is a combination of planning, budgeting, financial consolidation, reporting, strategy planning, and business scorecard tools (Bose, 2006). Figure 7 below shows the terms also meaning enterprise performance management used in the industry by organizations and experts.

Companies operate in a tough and competitive world. Companies are customer driven and customers are treated like royalty trying to attract them to purchase goods and services (Bose, 2006). Capturing and retention of customers is seen as one of the

biggest critical success factors for a business, for which systems such as Customer relationship management (CRM) was created. This service helps to sustain and build long-term relationships with customers adding more value for customers and the business (Rowley, 2004). In the recent past amounting to several years, not only customer relationships management systems but also enterprise resource planning (ERP) systems, along with applications like supply chain management (SCM) were used to capture every business transaction of the organization. These systems fetch and store valuable information from which significant insights can be extracted (McAdam and Galloway, 2005).

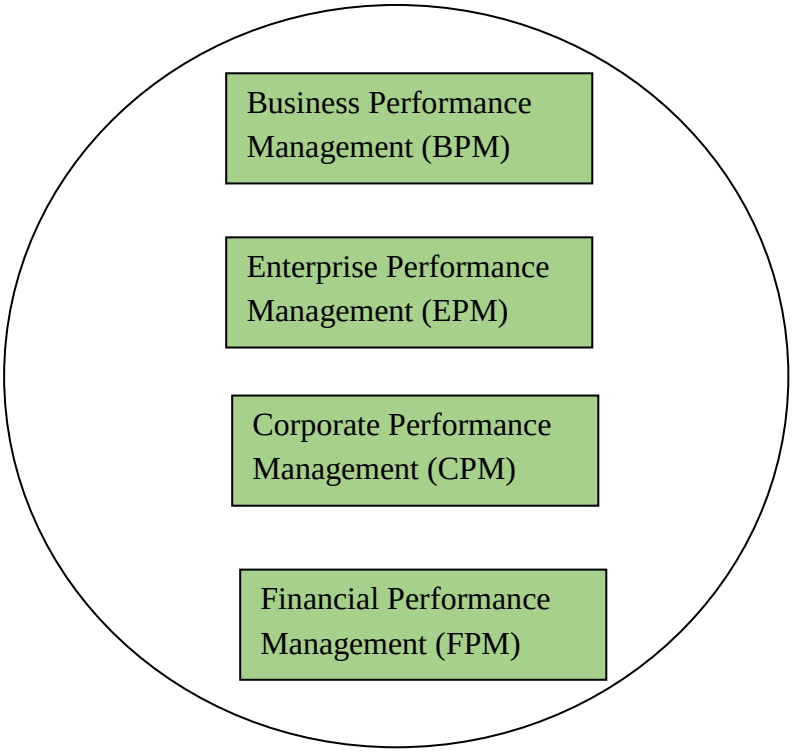


Figure 7. Acronyms denoting performance management applications.

From this wide variety of data collected, insights such as customer preferences, buying patterns, business process information can be derived. The problem arises when all these data has to be organized and integrated to give business owners, managers and other key decision makers the appropriate key indicators to measure and act in a quick way. The notion of having to knot operational data from application enterprise systems with goals and strategies benefited decision makers by providing a clearer picture and visibility into performance against the attached objectives. (Bose, 2006)

Figure 8 below shows the business process framework involved in Financial Performance Management. The first stage is framing the goals and objectives of the organization. The second stage is where strategic, financial and operational plans are created. The third stage is closing of the books on a periodical basis, for example; on a quarterly, monthly or yearly period. After the books are closed, the next stage is where

the financial results and disclosures are made available to stakeholders. In this stage, the key performance indicators are tracked. The last stage is about analyzing the financial and operational results.

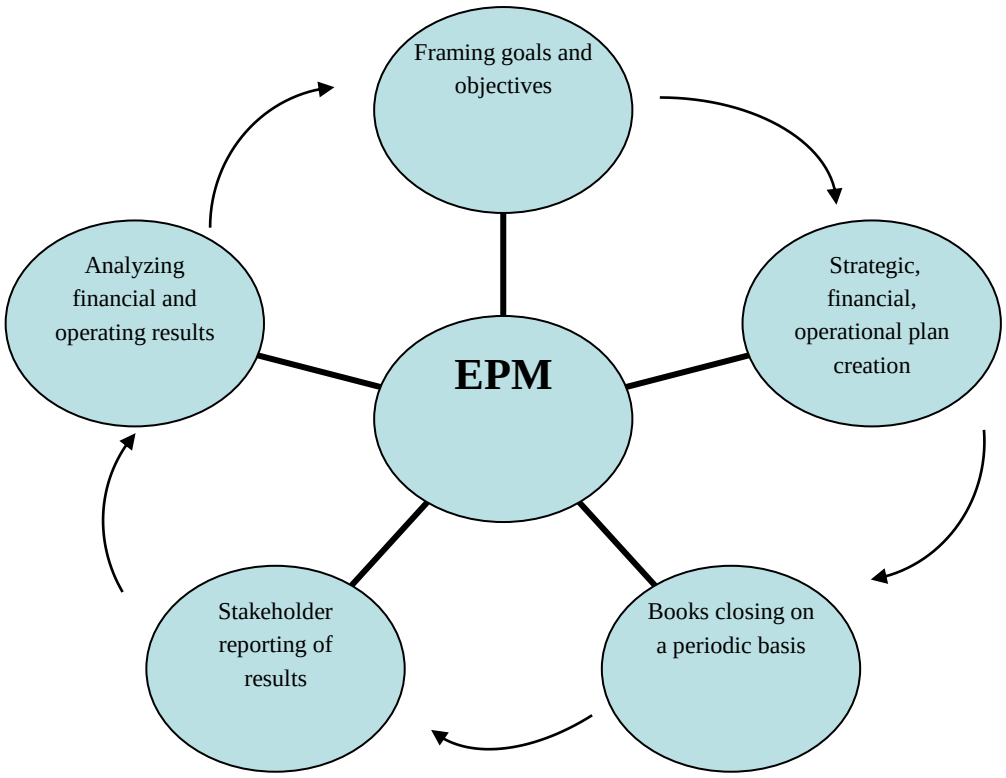


Figure 8. Business process framework involved with FPM.

The managers also had to ensure that these strategic goals were met and so they turned to business analytics based corporate performance management analytics to maintain a track of enterprise behavior and budget targets (Schultz, 2004). With EPM enabled by analytics, managers can analyze the company at any instant of time, instead of becoming aware on the situation at a monthly or quarterly period. Fetching ongoing information on the performance of a company has become the priority for organizations seeking enhanced visibility into operations (Singh et al., 2000). Instead of simply reflecting on what had happened, this kind of "management in advance" and a proactive approach of EPM allows managers to act in the current situation having access to real-time data. EPM provides visibility for company to maintain its strategic focus. After a corporate strategy is set up, the company must determine how well the strategy is being executed over time. According to (Reh, 2005), key performance indicators (KPIs) enable an organization to examine spots of improvement and good performance. Table 1 below gives examples of key performance indicators for three strategic focus areas.

These are just examples and not the entire list of measures. KPIs reflect the critical success factors of an organization. The selection of KPIs must reflect the organization's goals and responsible for its success and also be measurable (quantifiable) (Bose, 2006).

Table 1. Enterprise Performance Management measures (Adapted from Bose, 2006).

Strategic Focus	Key Performance Indicators - examples
Cost Leadership	• Cost measurements like production and deliver cost • Cycle time such as production time, time taken to service customer • Conformance to product standards • Profitability
Product or Service Differentiation	• Time to market – a new product or service • Product or service customization • On-time delivery • Customer complaint management
Growth	• Best practices knowledge sharing • Customer acquisition and retention • Share of market

Enterprise Performance Management, is both a technology and methodology that aims at the systematic generation and control of an organization's performance. A performance management system consists of four main activities namely performance planning, taking action to control performance, performance measurement and performance rewarding (Melchert, Winter, & Klesse, 2004). EPM integrates ideas from performance management with BI, to make actual performance information available in real-time to relevant stakeholders. EPM makes use of a separate data management level to harvest data from operational processes and provide it to business intelligence applications which includes planning, dashboards, scorecards, reporting and analysis (Limburg, 2010). The important factor for understanding the bottom line effect has been contributed to identification of appropriate KPIs and also by aligning them with company strategies (Toni et al., 1997).

An effective EPM solution helps finance teams and CFOs in particular to better plan, strategize, analyze, optimize, close and disclose results. This helps to increase revenue and profitability.

2.3.2 EPM Solution Capabilities

EPM solution capabilities address multiple business needs such as rationalizing investment, aligning work with strategic objectives, managing projects and resources effectively, gaining visibility and control over projects. There are four basic concepts at the realm of corporate performance management. According to (Wade & Recardo, 2001) and (Peters, Wieder, Sutton, & Wakefield, 2016) managers with the highest return on equity are attracted to these concepts:

1. A well-defined and communicated business strategy is adopted by top managers.
2. The gaps between organizations, technology, and process architectures are reduced. The company performance is greatly enhanced by closely aligning each element within each architecture.
3. All activities are aligned from top to bottom by top managers within the organization. If any activity does not hold value, it is either outsourced or eliminated.
4. A specific set (more than 10, less than 30) of key performance measures that covers a diverse set of performance categories (e.g., employee satisfaction, customer satisfaction, productivity, growth, financial results) are adopted by top managers.

Beyond having a strategy, top financial performers stress on a performance measurement system that ties all aspects of an organization from boardroom to factory floor- to strategy. This is called as “alignment management”. The combination of choosing a business strategy and combining it with a discipline of alignment leads to good financial results – greater than 15% return on equity over multiple years. (Wade & Recardo, 2001)

Table 2 below gives an overview of the types of performance management systems currently in use. The two areas a performance management system is used are, analytical and operational. For analytical activities, a performance management system can be used to give an estimation on expenses, profitability, feasibility analysis, process control and data analysis. The analytical functions enabled by BPM or EPM systems are utilized for predictive analysis. (Olszak & Ziemba, 2015)

Table 2. Types of performance management systems.

BPM	Business Needs	Opportunities	Addressees	Technologies
Analytical	Expediture and Profitability Estimates	BSC and Reporting	Organisation and its Partners	BI
	Basic Feasibility Analysis	Pre-defined Analysis	Organisation	BI
	Data Research	Transactions Analyses	Organisation	BI
	Prediction	Advanced Analyses and Statistics	Organisation	BI
	Monitoring	Alerts	Organisation and its Partners	BI
Operational	Results Calculation	Budgeting, Planning and Forecasting	Finance experts	ERP

In the case of using EPM systems for operational activities, they are used in framing indicators that target the current activities of the company. Activities such as planning, budgeting and forecasting are performed by the system.

The difference between strategy and execution is bridged in several ways using EPM. Organizations can keep up with the competitiveness of their rivals and exploit market opportunities more efficiently. The following are some of the key benefits of an EPM solution (Eckerson, 2003):

- **Improvement in communication**

  Executives of organizations are provided with an effective mechanism to communicate business strategy to senior executives and managers at all levels of organization by creating models and performance metrics that are aligned with corporate goals and objectives.

- **Improvement in control**

  With an EPM solution, executives can alter plans, correct or improve operations in a timely way by having accurate information on market conditions and the position of operational processes.

- **Improvement in collaboration**

  Ideas and information is passed on both vertically between various levels in the organization and horizontally within departments and groups. EPM supports a two-way exchange of information.

- **Improvement in coordination**

  Coordination amongst business units and functional groups is enhanced, otherwise acting independently, thus enabling sharing of resources and information.

2.4 Creating Value with EPM

An EPM software automates processes such as planning both for long-term and for the short-term to enable real-time decision making. The software also automates collection of historical records which are then used with projected performance data, so that managers can perform simulation modeling, what-if analysis, and quick forecast of results. A huge amount of time and effort can be saved by preventing manual data compilation activities by enabling automated compliance reporting. The quality of reports is stable due to the principle of "one version of the truth". The latest developments in the EPM circle has enabled managers to emphasize more on helping decision makers make better decisions, so that value is created for stakeholders. (Sharman, 2016)

The key decision makers will have to comprehend the importance of performance management systems and the technologies underlying it. In today's business environment, it is important for managers to understand and realize technologies on how to utilize them and deal with the issues that are related to efficient management within the bigger umbrella of enterprise performance management.

Given the importance of EPM in today's business environment and the underlying management data systems technologies that are used to build and use them, the managers need to effectively understand these technologies in terms of how they are used and the issues that are related to their effective management within the broader context of EPM.

Figure 9 below shows the elements involved with a performance management cycle. There are four elements namely; planning, measurement, analysis, review/improvement. The planning element involves setting up of goals which are inferred from organization strategy and are operationalized through key performance indicators. The timeframes for the defined strategy are decided upon. The second element, measurement, includes measuring the current status. Here, sometimes the key performance indicators are broken into performance indicators or performance indicators are consolidated into KPI's. The third element, analysis, is interpreting, evaluating, projecting and forecasting from the current status. The deviation from the actuals goals set are analyzed and corrective measures are taken. What-if scenario testing is performed in this stage.

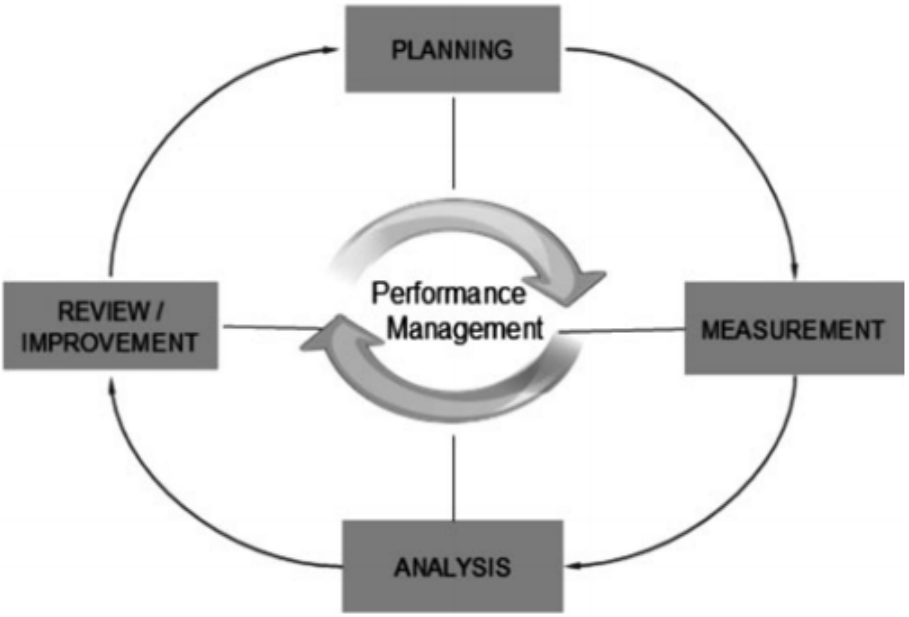


Figure 9. Elements of Performance management (Adapted from Samsonowa, 2012).

The last element being review/improvement is identifying activities that could be implemented based on the inference from the previous analysis element. This could include prioritizing or changing organizational goals. (Samsonowa, 2012)

2.4.1 EPM Framework: Four-step process

The EPM framework is a four step process that is based on the elements of a performance management system that is shown below in *Figure 10*. It is closed-loop that aims at converting business strategy into decision making insights and action. In this circular process the first two steps; strategize and plan depict the strategy phase and the last two steps; monitor and act and adjust involve the execution phase. When all these steps are executed in an organized manner, they help enhance communication, control, collaboration and coordination which are shown in *section 2.3.2*. The steps involved are:

1) **Strategize**

Key drivers of business value along with ways to measure the value is defined in this phase. The drivers could be high quality, high customer satisfaction or even restriction in the number of defects in products. The measures of business drivers are called key performance indicators. These are metrics that help define and showcase future performance. KPI's help executives take action and drive performance to have positive outcomes. In this phase, the mission of the company is redefined and accomplished with the goals and objectives set.

2) Plan

After the strategy is set, executives will have to decide on the plan and allocate resources to execute the business strategy. At this stage, new initiatives can be taken or existing ones can be reaffirmed. In this phase, bigger corporate targets are broken down into smaller targets and scenarios thus creating smaller projects and initiatives across the organization.

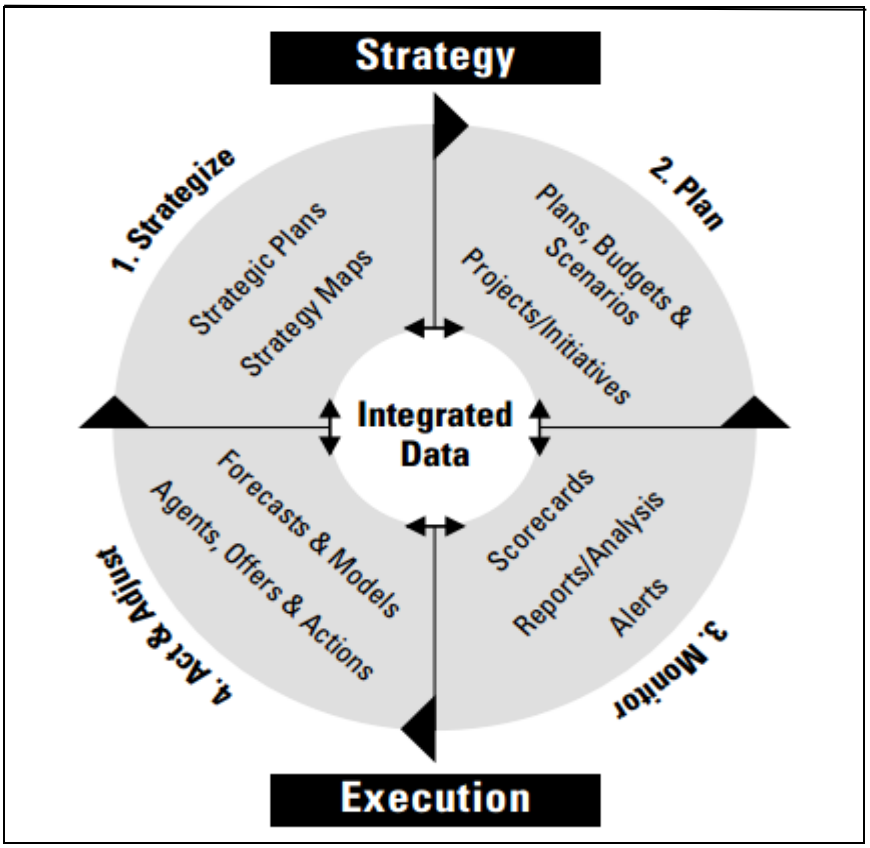


Figure 10. Enterprise Performance Management Framework (Adapted from Eckerson, 2003).

3) Monitor

The monitoring phase encompasses the execution cycle where the strategies and plans set in the previous two phases are carried out. The performance of the organization is analyzed and monitored. The measures set in the planning process are monitored and analyzed against the performance in relation to the goals and objectives. The timely manner in which information on current business processes affects the decision making process. The business intelligence system that is coupled with the EPM system determines the rate of reception of new business process data. Data warehouses and business intelligence systems are the technologies that help to monitor enterprise performance. Dashboards and scorecards, are some of the common ways to monitor

performance data. Even alerts can be set up to inform relevant teams when results are below or above expectations.

4) Act and Adjust

The last phase which comes under the umbrella of the execution cycle is the act and adjust phase. This is deemed to be the most critical phase. Setting up process and plans is different but when the situation reaches an unexpected point, action has to be taken to correct it.

2.5 Key Roles of RTBI in EPM

The applications and tools available to different departments of an enterprise are evolving every year with newer functionalities. Improved technology can offer more efficient delivery models, better functionality and improved performance. However, there is a need to understand the differences between RTBI tools and EPM solutions. Enterprise performance management and business intelligence are very closely associated and also partially overlapping. The two terminologies can be easily mixed up and so understanding the differences can help companies make better decisions. As seen in the previous sections, BI or RTBI tools are used across the organization for analyzing and accessing information. A normal BI solution would include OLAP, decision support systems (DSS), statistical analysis and forecasting. *Table 3* shows a comparison of traditional BI and BI for EPM. EPM helps operational decision making more proactive and supports a variety of businesses with BI.

Table 3. Comparison of traditional BI and BI for EPM (Adapted from Ballard et al., 2005).

Category	**Traditional BI**	**BI for EPM**
Implementation	Departmental	Enterprise wide
Focus	Historical	Timely, right-time, or real-time
Decisions	Strategic and tactical	Strategic, tactical, and operational
Users	Business analysts	Everyone
Orientation	Reactive	Proactive
Output	Analyses	Recommendations and actions

Process	Open-ended	Closed-loop
Measures	Metrics	KPIs and actionable metrics
Views	Generic	Personalized
Visuals	Tables, charts, and reports	Dashboard and scorecard
Collaboration	Informal	Built-in
Interaction	Pull (ad hoc queries)	Push (events and alerts)
Analysis	Trends	Exceptions
Data	Structured	Structured and Unstructured

Business intelligence has enabled organizations to access, analyze, and utilize data for decision making. Even with the traditional BI system which is standalone and can be used for EPM processes, performance management capabilities could be performed.

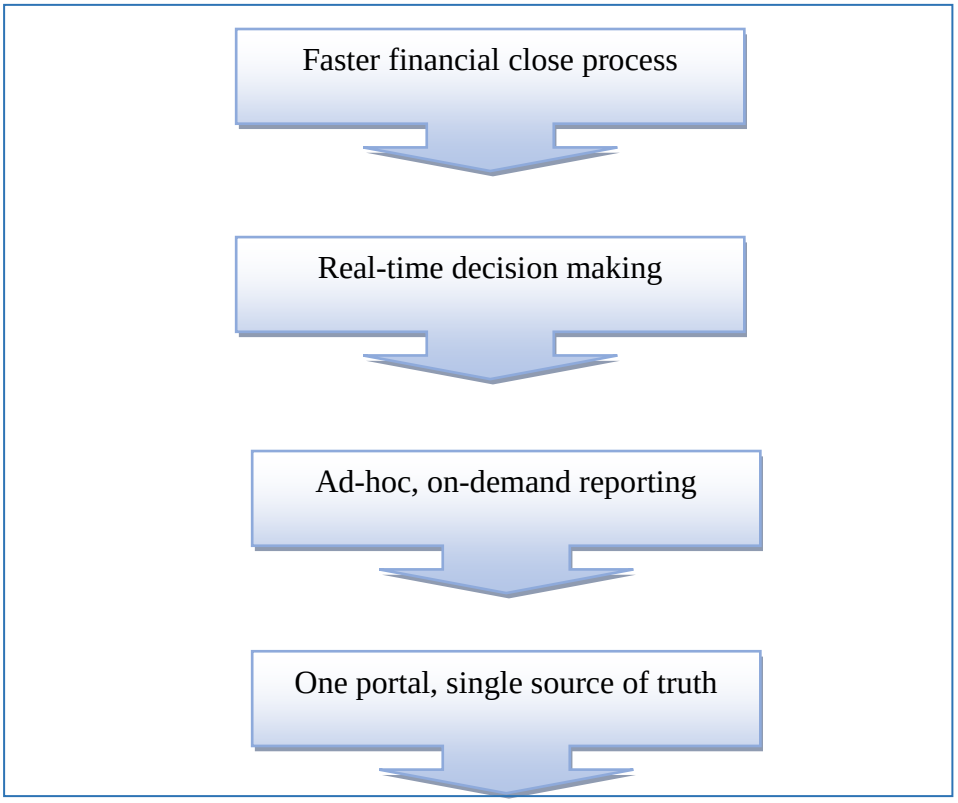


Figure 11. Key roles of RTBI.

Figure 11 above shows some of the key roles of RTBI in a performance management application. Real-time business intelligence enables faster financial close process because of data availability. The closing of financial books is these days seen as a competitive advantage than just as a regulatory measure. (Sharman, 2016)

However, the efficiency of having such a combination is in question. On the other spectrum, having a dedicated in-built BI system within EPM with added functionalities such as advanced analytics and predictive capabilities coupled with real-time information proves to be an asset for deployment. (Rouhani, Ashrafi, Zare Ravasan, & Afshari, 2016)

3. SYSTEMATIC LITERATURE REVIEW

3.1 Overview of Systematic Literature Review

According to Kitchenham (2007), *"A systematic literature review (often referred to as a systematic review) is a means of identifying, evaluating and interpreting all available research relevant to a particular research question, or topic area, or phenomenon of interest"* (Kitchenham & Charters, 2007)

The fundamental studies of the systematic literature review are addressed as primary studies, and secondary study denotes the systematic literature itself.

A particular research methodology is directed from a systematic review wherein evidence that is present is collected and validated that concerns a particular field of study. An SLR demonstrates a way to validate and comprehend data and analysis that is present for particular research questions, topics or field of interest (Kitchenham & Charters, 2007). According to (Kitchenham, 2004), systematic literature provides a trustworthy, fair and unbiased validation of a topic in research by utilizing methodology that is auditable.

The following sections will explain parts of a systematic review in relation to this thesis research study. It will guide the audience on research classification, research methods, data collection approaches and review protocol being utilised. For conducting the SLR, review protocol (*chapter 3.4*) acts as a foundation.

However, information about the history of systematic reviews is beyond the scope of this study and will not be covered. Khan et al. (Khan et al. 2001), Kitchenham (Kitchenham 2004) and Biolchini et al. (Biolchini et al. 2005) describe the different phases of an SLR.

The process of a systematic literature review consists of three phases namely: the first stage involves planning for the review (*chapter 3.2*); the second phase involves conducting the actual review (*chapter 3.3*) and the third and final stage is the reporting the review (*chapter 4).*

3.2 Planning the Review

The stage of "planning the review" commences by choosing and confirming the purpose for the review. The purpose of this review is to find the effectiveness of real-time business intelligence on enterprise performance management. A predefined search strategy will be undertaken to conduct a systematic literature review. The completeness of the search to be assessed must be allowed by the search strategy. For this study, the reasons for choosing a systematic literature review are outlined below:

- To summarize the evidence that is existent regarding real-time business intelligence and enterprise performance management solutions. Observatory conclusions are done based on individual studies and linkages are found based on the research question. For example; real-time business intelligence along with automation of business processes can enhance performance management.
- Areas for further investigation can be suggested to identify any gaps in current research. Since performing a systematic review requires extensive reading of primary studies and various other articles in relation to the study, suggestion to perform more research on a particular unclear domain area could be suggested. In this case, since there are not many studies linking real time BI to EPM and also addressing decision latency issues could be potential areas of focus in future.
- This research study linking EPM and real-time BI can in future be appropriately positioned to serve as a framework or background for new research activities.

The extent to which primary studies exists will be reviewed. The planning stage consists of three other sections which will be explained below:

1. **Identification for the need of a review**

The first step involved in planning the review is to identify the need for a review. This step is crucial since it disallows duplication of research. It is also to make sure every review tackles an appropriate issue (Khan et al. 2001). According to Greenhalgh (1997), checklists that are available could be used to assess quality of reviews. The checklist questions to assess study quality can be found in *Appendix A.* The need to conduct the review for the chosen topic arises after an initial search to find any similar reviews currently occurring or that are already existing is finished. Only after verifying and confirming the absence of such a review, the review is planned to be conducted. The problem description and the motivation to conduct this study is explained in *chapter 1.2* and *chapter 1.3* respectively.

2. **Review Proposal - Preparation**

General information is provided by the proposal on the idea and background behind the review. The background information of the study can be found in *chapter 1.1.* The

research question(s) along with the other dimensions of the proposal are significant. The research question can be found in *chapter 1.4.* Information on possible inclusion and exclusion criteria for study selection is provided by the review method. The inclusion and exclusion criteria for the study selection can be found in *chapter 3.4.3.* The information sources that will be searched are also included. The list of information sources from which primary studies and reference articles, journals etc. are chosen from is mentioned in *chapter 3.4.3.2.* As a base for the systematic review to take place, the review protocol is used. The next sections deals with the development of the review protocol.

3. Review Protocol - Development

To plan and execute the review, the review protocol (found in *chapter 3.4*) serves as a guideline to follow so that evidence is chosen, gathered, and appraised. The review protocol constitutes (Khan *et al.* 2001):

1. Background and Motivation
2. Review questions
3. Search strategy, search terms and search sources
4. Study selection criteria
5. Study quality assessment checklist
6. Synthesizing evidence

The components of the review objectives helps to define the search strategy. After the strategy for search and collection of evidence is completed, consideration for inclusion and exclusion criteria is done. From study selection until reporting and recommendations stage, the quality of the study can be judged. The synthesis of extracted evidence considers the extracted evidence to be merged and refined; the size, validness of the studies and differences within the studies is studied. The second phase "Conducting the review" is the next step. This is explained in the following section.

3.3 Conducting the Review

This chapter will give information on the conducting of the systematic literature review. A detailed discussion about the similarities and differences between various studies will also be presented. The systematic review is conducted in detail and in an unbiased manner. This study has synthesized and summarized existing work in relation to the research question. A replicable, scientific and transparent approach is being utilized to minimize bias.

The review protocol listed in chapter 2 serves as the foundation for conducting the systematic review. The review protocol consists of the research question and the review methods.

An outlined search strategy lays foundation to an SLR that targets relevant literature in detail. Study inclusion and exclusion criteria are described as a prerequisite for each primary study and the quality assessment is defined. The systematic review is maintained to be transparent and replicable. Search criteria, search items and search strings are included in the documentation. It also inculcates mentioning of the databases and various sources used to retrieve studies.

The primary studies chosen possess strength and credibility in its result in order for the literature review to provide information. The stage of data synthesis helps to find out differences between the compared studies.

3.3.1 Initial Study

An initial preliminary study was performed prior to the start of work on different research methods and how systematic literature review in particular is performed in the software engineering field. Observational studies using electronic databases, journals, conference papers and literatures were performed in the areas of real-time business intelligence and enterprise performance management applications. An understanding of performing a literature review on the chosen topic was enhanced during this phase of study. This paved the way to proceed further and provide an introductory study for the master's thesis.

3.3.2 Research Classification

A recognized and methodological process is followed in this study which helps to discover inconsequential facts and insights. The objective of this thesis is to establish the linkage and benefits of real-time business intelligence on enterprise management solutions. This research study is classified as *descriptive studies* since existing knowledge within the fields of real-time business intelligence and enterprise performance management is reviewed and evaluated. It describes the individual literature and then calls for reasoning by the researcher to find the linkage.

It is usually based on the kind of research undertaken, that different researchers choose research methods to suit their application. Research methods can also be combined to get results that are reliable (Berander 2004; Creswell 2003). The next section involves explanation of the research method used for this study.

3.3.3 Research Method

The nature of the study determines the research method to be used. The research method used in this study is *case study* method wherein the effectiveness of real-time business intelligence on enterprise performance management is studied and evaluated. This method has helped to provide ways to compare and show the benefits of real-time

business intelligence on the performance of an enterprise compared to a normal business intelligence solution.

The case study research method has enabled deeper exploration of the given problem. The situation on which the study was performed could be related to any enterprise irrespective of its operational or functional area. After choosing the case study research method, some method has to be utilised to gather the data. The data collection approach that has been used in this study is discussed in the following section.

3.3.4 Approach for Data Collection

The data collection approach used in this study is a *qualitative approach*. Qualitative approach is used for this thesis study and is more suited than experiments since, for example, a new technology (real-time business intelligence) is tested to discover the effectiveness to perform a business function (performance management). In this qualitative approach, a researcher question was posed and the outcome of the search could yield a wide variety of information. By gathering information on a personal level in this qualitative research, the situation and context was comprehended. Based on own experience and knowledge from the collected data, an interpretation is deduced. The intent of using a qualitative approach is to develop a theory or pattern based on collection of studies that are based on experiences and background. A qualitative approach for data collection consumes a lot of time for research collecting multiple types of data.

3.4 Review Protocol

Review protocol is a plan that shows the way a systematic literature review is conducted (Kitchenham & Charters, 2007). This served as the backbone and foundation to a systematic literature review. The systematic review started by specifying the review protocol which in turn specified the research question and methods that would be used to address the review. The different parts of the review protocol is mentioned briefly in the following sections (Kitchenham & Charters, 2007):

3.4.1 Background and Motivation

The background section contains information that was undertaken at the initial stages of the systematic review. The *chapters 1.1 and 1.3* will explain this section in the systematic review.

3.4.2 Research Question

The main review question is defined in the review protocol. A clear and narrow research question is chosen by limiting the scope of the literature study. The review question is created depending on the outcomes of the studies. In the SLR the effectiveness of real-time business intelligence on enterprise performance management is studied. For detailed information on the review question, refer to *section 1.4*.

3.4.2.1 Generating a Search Strategy

It is essential to plan and follow a search strategy to retrieve primary studies related to the topic. Search strategies were usually iterative.

The systematic literature review is mainly targeted towards studying the effectiveness of real-time business intelligence in enterprise performance management. The search strategy had to revolve around the main topic, thus requiring search terms that will help retrieve studies related to it. The search terms were applied to various databases that are rated high in the engineering discipline. The following sections explain the search terms used and the resources utilised to retrieve the studies.

3.4.2.2 Identification of Research

The identification of primary studies related to the thesis topic was a very challenging process. It consumed time and effort. The main objective was to collect as much material as possible both published and unpublished. The search was done in an unbiased manner so that the review findings could be credible. One of the main features of a systematic literature review is the rigorous manner in which the search process is conducted. This distinguishes it from a traditional review.

3.4.2.3 Search Terms

In order to include literature that is relevant to the topic of choice, it is necessary to have search terms defined. This had helped to retrieve relevant articles and studies from various databases. A structured approach was needed to apply the combination of search terms to databases to get the desired results. The search terms have to be combined in various patterns to perform trial searches. The search terms cover the research question and also words picked from the abstract and title of the review. After retrieving primary studies, search terms were derived from them that was related to the topic selected. The reference list of primary studies were used to retrieve more studies. The search terms are also combined using Boolean operators such as ‘OR’ and ‘AND’ to create search strings. The search terms used to identify primary studies as well as the electronic databases used in the literature review are listed below in Table 4.

Table 4. Search terms used to retrieve primary studies.

Count	Search terms
1.	Real-time business intelligence
2.	Business-intelligence
3.	Enterprise performance management
4.	Corporate performance management
5.	Real-time BI
6.	Business intelligence effectiveness
7.	Real-time business intelligence effectiveness
8.	Advantages real-time BI
9.	EPM
10.	CPM
11.	BPM
12.	Business performance management
13.	1 (Real-time business intelligence) AND 3
14.	1 AND 9
15.	42 AND 3
16.	3 AND 5
17.	4 AND 5
18.	3 AND 4
19.	5 AND 11
20.	1 AND 12

3.4.2.4 Search Resources

The search resources comprises many online databases which provided information about various scientific journals (including company journals), grey literature (technical reports, work in progress), conference proceedings, research registers and the internet. Even in the online databases, boolean operations such as ‘AND’ and ‘OR’ were used to derive results. The search was done with respect to filters such as author’s name, subject, title and relevancy. The search process is documented so that the risk of missing out on important primary studies is reduced. The list of search resources utilized can be found below:

The online sources that were used for the search of primary studies using the search terms are mentioned below in *Table 5*.

Table 5. Online sources.

Count	Online sources
1.	ACM Digital Library
2.	IEEE Xplore
3.	Ei Compendex
4.	Springer Link
5.	ScienceDirect (Elsevier)
6.	Google Scholar
7.	Inspec
8.	Grey Literature (studies not found from computerized search, for example: Master thesis, PhD thesis, online sources etc.)

3.4.3 Study Selection

After the search for primary studies that is connected to the research topic was completed, the studies were taken and checked for their connection to the research topic. The criteria defined for inclusion and exclusion of studies was followed. This study selection process involved various stages. This involved citation, retrieval of full reports and related citations, finding and assessing primary studies that satisfy inclusion criteria. Following the selection of primary studies, the quality assessment of primary studies was conducted for them to be included in the systematic review.

The following sections describe the study selection criteria used, assessment of study quality, data extraction and data synthesis processes.

3.4.3.1 Study Selection Criteria

Study selection criteria is set to identify and ensure primary studies provide evidence about the research question. The study selection criteria was fixed during the protocol definition so that any form of bias is prevented. The study selection criteria was however, refined during the search process. Based on the research question, inclusion and exclusion criteria are set.

The study selection criteria comprises inclusion and exclusion criteria and they are explained below in *Table 6* and *Table 7*.

Table 6. Study inclusion criteria.

Count	Criteria
1.	The article should discuss about real-time business intelligence and its impact on performance management.
2.	The articles must be full text articles.
3.	The article is included if it compares business intelligence and real-time business intelligence.
4.	The article is included if it describes about performance management.
5.	The articles must be either in industrial or academic settings
6.	The articles included having a publication date between 1990 and 2017.

Table 7. Study exclusion criteria.

Count	Criteria
1.	Articles not fulfilling the inclusion criteria are not considered.
3.	The article is included if it compares business intelligence and real-time business intelligence.
4.	Relevant papers having incomplete information are excluded.
5.	Keywords not present in the headline or abstract of articles are excluded.

3.4.3.2 Study Selection Process

The study selection process consisted of multiple stages. The selection criteria was initially set liberally based on the title and abstract but since some abstracts did not meet good standards, it was also required to read the conclusions. Some of the inclusion and exclusion criteria included practical issues such as language, authors, setting, date of publication etc.

The objective of the selection of studies was to identify articles and studies that related and answered the research question for which the systematic literature review is done. The findings and inferences of the review will be based on the studies selected. The pre-

defined inclusion and exclusion criteria streamlined this process and helped to prevent any kind of bias during selection.

The selection of primary studies was an iterative process and was mostly covered with the help of electronic databases. The full text of primary articles were retrieved after initially scanning through the title and abstract to find relevancy to the research topic. Table 8 below shows the number of primary studies retrieved from individual databases.

Table 8. Primary studies retrieved from different databases.

Database	**Studies Retrieved**	**Studies Selected**
IEEE Xplore	8,633	15
ACM	9,705	12
Ei Compendex (Elsevier)	4,060	10
Springer Link	24,233	14
ScienceDirect	37,017	16
Google Scholar	23,050	30
Inspec	1,060	6
Total studies	107,758	103

The primary studies have been assessed individually to validate whether the studies meet the inclusion criteria. As seen from Table 7, the number of primary studies retrieved from an initial search was huge. However, due to factors such as non-relevancy to the research question, incomplete information on required topics, after reading introduction/conclusion, the number of selected articles was trimmed to 103. Out of the potential 103 articles, after reading the title, abstract, introduction and conclusion, 68 articles were rejected. There were overlapping articles since different databases were involved in the search process. The remaining 35 articles were read in full detail and 18 studies were included as primary studies. The reason for not including the remaining 17 studies was mostly due to repetition of information and slight

deviation from the topic of concern. The flowchart below in *Figure 12* demonstrates the study selection process. *Table 1 and Table 2* in *Appendix B* give information on the primary studies selected. *Table 3* in *Appendix B* outlines the reasons for the rejection of the final 17 studies.

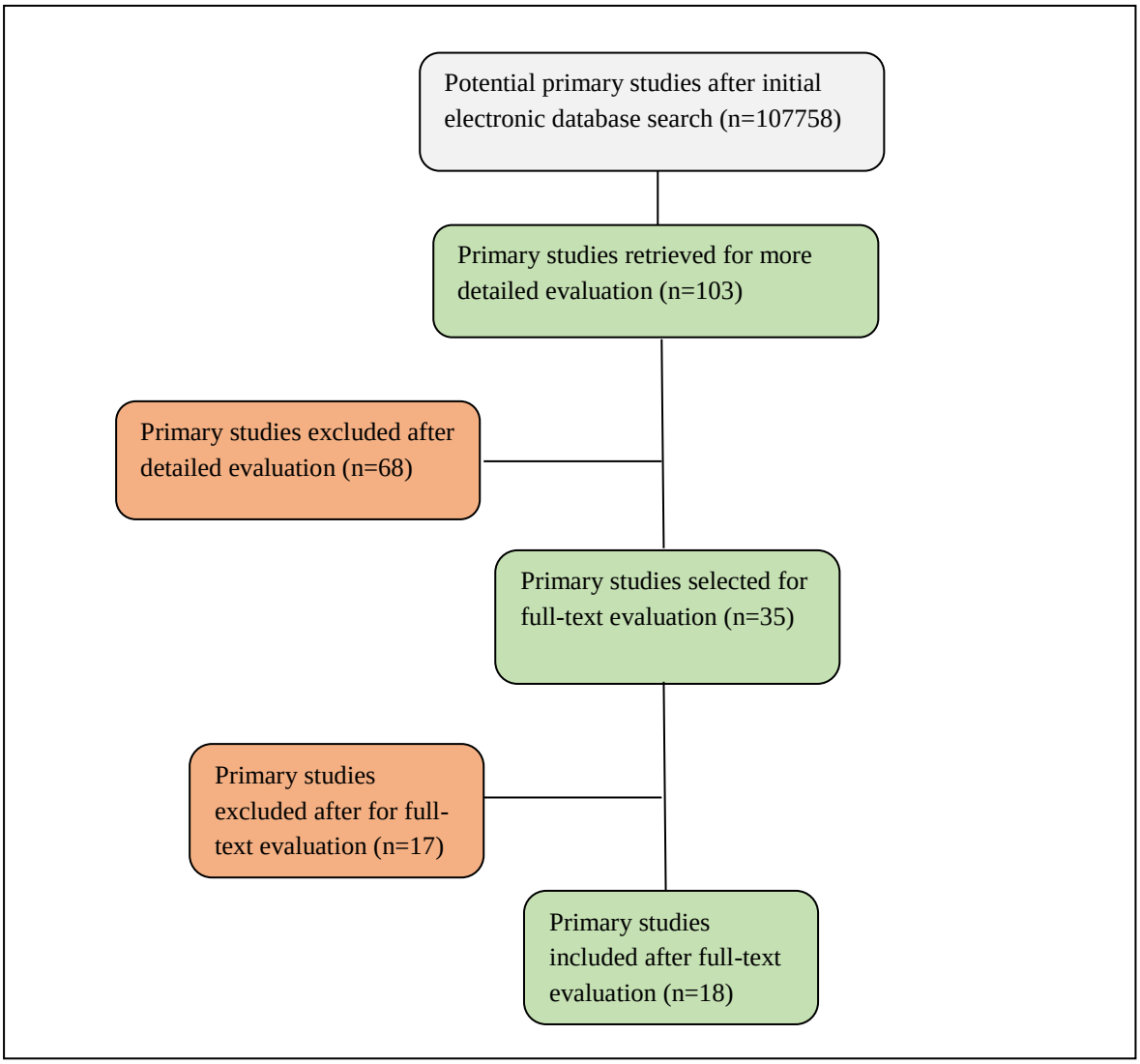


Figure 12. Study Selection Process.

3.4.4 Assessment of Study Quality

After defining the general inclusion and exclusion criteria it was important to assess and validate the 'quality' of primary studies. The study assessment had helped to provide more detailed inclusion and exclusion criteria. It also helped to weigh the importance of individual studies. The characteristics of the primary studies were validated based on a list of questions. The questions assesses the study research based on the inquiries in the primary studies. The checklist helps to check if the different types of biases were taken into account during the study and the preventive actions undertaken to solve them. The complete list of questions can be found in *Appendix A.* The next step is the data

synthesis stage where information from different studies is merged and results are summarized. This is explained in detail in the following section.

3.4.5 Data Synthesis

Once relevant information is gathered, it was synthesized to get a broader view of the study. It involved collating and summarization of results found in primary studies. Synthesizing studies involved combining conclusions. The approach used in this study for suited for qualitative synthesis was *line of argument synthesis*. In this case, the set of studies is analysed as individual studies and then as a whole. The individual studies looked at part of the research question and conclusion in this thesis study was done based on the research topic as the bigger picture. More information on data synthesis of this thesis is present in *Appendix B*. *Table 1* in *Appendix B* describes the characteristics of the finalized primary studies.

The studies involved can be heterogeneous in terms of processes followed, study designs, populations, interventions, methodology and outcomes. Therefore, primary studies were fused in tables with qualitative synthesis. It was clear from the *table 1*, that most of the primary studies were case studies that focussed on the research question. The subject types were professionals. The study duration was not found with the articles, however, few had possessed a valid start date without an end date. *Table 2* in *Appendix B* summarizes the study designs used by the primary studies. The quality of the primary studies varied as it is evident from the tabular data.

The second stage signals its end with the data synthesis of different primary studies. From the data synthesis and evidence from the tabular data previously mentioned, the findings of the systematic literature review is presented in the following section.

4. RESULTS: COMBINING EPM WITH RTBI

4.1 Characteristics and Assessment of included studies

After selecting studies that would be relevant for conducting the systematic literature review with the help of selection criteria and other processes, individual characteristics and assessment of the studies will be presented below.

The main focus points of the included studies are mentioned in *Figure 13* and *Figure 14* below. The studies revolve around real-time business intelligence and performance management. Some studies have been pooled together since the subject and objectives were found to be common. The primary studies listed below can be referenced from *Appendix B.*

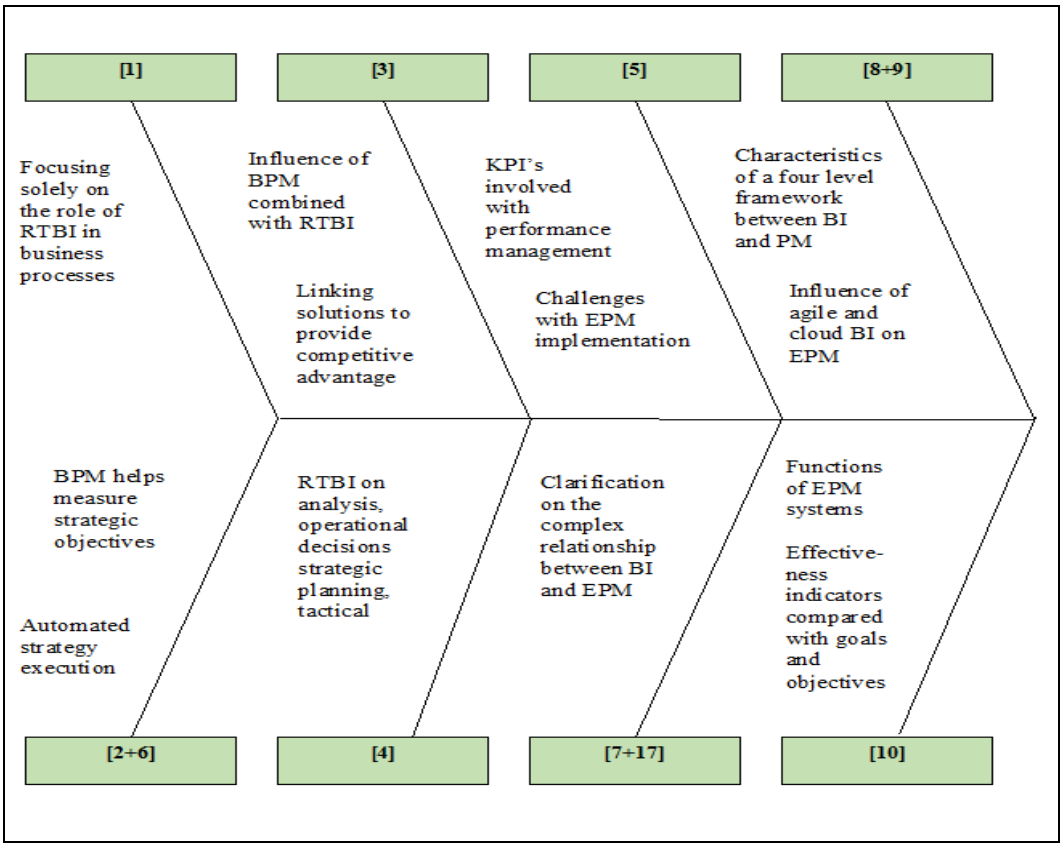


Figure 13. Focus of included primary studies (1).

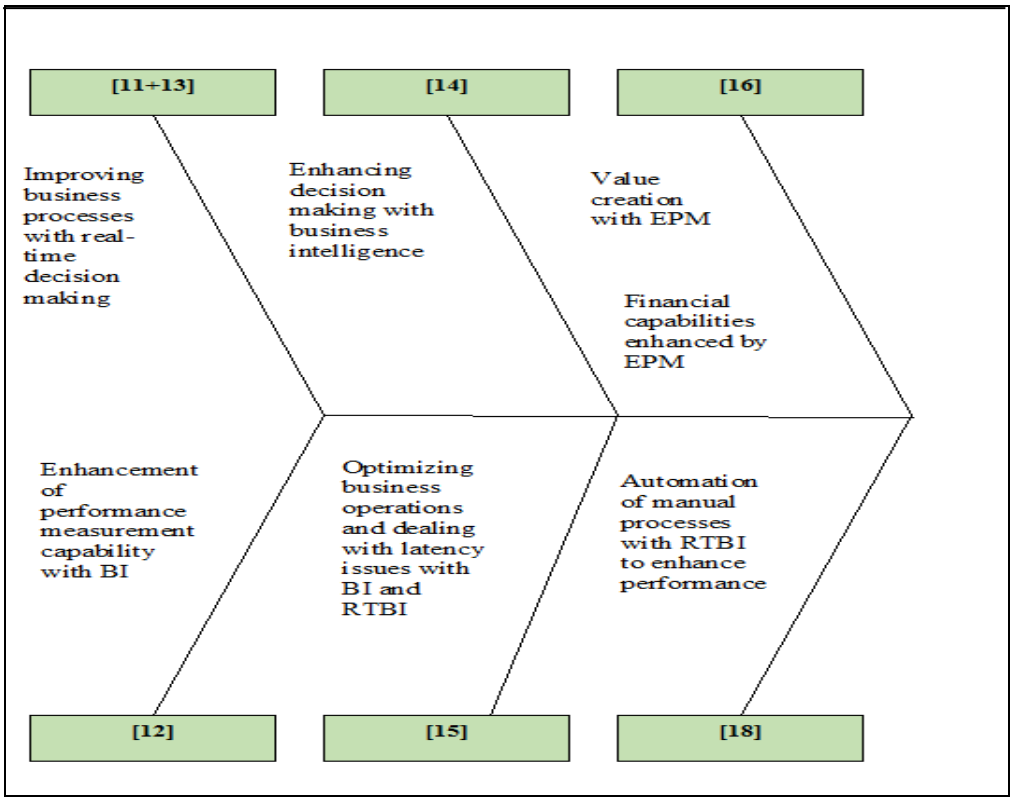


Figure 14. Focus of included primary studies (2).

After synthesizing the evidence from these studies a common assessment with respective outcomes are listed in *Table 9*. The derived impact and results of the studies will be integrated and presented at the following sections in this chapter.

Table 9. Assessment of included studies.

Primary studies	**Outcome and assessed results**
[1]	Criteria and advantages of RTBI; provides a base for positioning EPM with RTBI; challenges
[2+6]	Influence of RTBI on EPM framework components; information on automation of strategy execution; organizational challenges
[3]	Effectiveness in terms of reducing costs and reducing decision making time
[4]	Providing information on demand
[5]	KPI's alignment with long term strategy; dealing with high volume of data and derivation of KPI's
[7+17]	Criteria to combine EPM with RTBI; support for business processes

[8+9]	Relationship between BI and the four level component framework: strategy, planning, monitoring, act and adjust
[10]	EPM functionalities and attributes; Identifying trends, calculating relationships, performing ratio calculations and analysing differences and abnormalities with real-time information
[11+13]	Real-time dashboards, scorecards, analytical and predictive capabilities improving business support
[12]	Performance measures on performance categories
[14]	Real-time integration is required to enable automatic data flow for EPM processes such as timely financial close and consolidation, budget planning, forecasting and management reporting
[15]	Decision making capabilities without latency issues; analysis, decision and action latencies
[16]	Faster financial close, ad-hoc, on-demand reporting enabled by EPM systems
[18]	Advanced analytics closing the gap between transactional and analytical systems

The *table 9* above gives a bigger picture of the assessed characteristics of the primary studies. The first study dwells on the criteria and benefits of RTBI. After analyzing the study, it was important to position EPM in relation to RTBI. So, every aspect of the criteria and benefit was merged with the working of an EPM system. The extensive review and research done in the study helped gain an understanding and led to the next *section 4.2*. *Figure 15* was mainly derived from the first primary study however, other studies such as from (Popeangă, 2012), (Panian, 2009) and (Eckerson, 2003) have also played a fundamental role of support. The study from (Panian, 2009) discusses more on the embedding of real-time analytic capabilities into business processes, (Popeangă, 2012) talks about real-time BI based on a particular industry but since each sub-topic related to the larger topic, a conclusion was based on how the independent functionality of the EPM application when it was coupled with RTBI made it effective. (Eckerson, 2003) mentions about integration of cross-domain data sources and how this stands as one of the main criteria for an EPM enabled by real-time analytics. (Agrawal, 2008) sums up all the points and describes the overall effects and the main idea for the criteria.

Studies [2] and [6] have been pooled together since they focus heavily on the impact of RTBI on the framework components of EPM namely; strategy, planning, monitoring and, act and adjust. The synthesis of these studies has particularly led to the role of aligning EPM with RTBI *(section 4.3)*. For example; the study by (Ariyachandra & Frolick, 2008), talks about the success factors for EPM (BPM), but focusses more on

the strategy component of the BPM framework. (Eckerson, 2003) similar to (Ariyachandra & Frolick, 2008), points out the success factors for EPM, but (Eckerson, 2003) goes a step further in his research to point out the challenges (*section 4.4)* facing performance management applications powered by RTBI. While studies from (Agrawal, 2008), (Azvine, Cui, & Nauck, 2005), (Hackathorn, 2004) and (Tank, 2015) talk more about the technical challenges involved in the processes regarding hardware and software compatibilities, (Eckerson, 2003) discusses more on the organizational and misconceptions that executives have while implementing an EPM solution.

4.2 Criteria to be met: Real-time Analytics and EPM

The software indicating the backing up of real-time business intelligence for an EPM application is generally required to satisfy the following three criteria. From the primary studies of (Agrawal, 2008), (Ballard et al., 2005), (Hartl, Jacob, Mbep, Budree, & Fourie, 2016), (Shi & Lu, 2010), and (Bogdana, Felicia, Delia, & others, 2009) the influence of business intelligence on EPM is studied and compiled together. In order for the criteria to be met wherein real-time business intelligence is applied, studies done by (Popeangă, 2012), (Panian, 2009) and (Eckerson, 2003) that emphasize on real-time intelligence and decision making were studied and linked to EPM. *Figure 15* explains the general criteria required after formulating the main idea from *Table 10*. *Table 10* is a synthesis matrix involving studies from (Agrawal, 2008), (Eckerson, 2003), (Panian, 2009) and (Popeangă, 2012).

Table 10. Synthesis matrix (1).

Main Idea	**Source [1]**	**Source [6]**	**Source [11]**	**Source[13]**
Criteria for real-time analytics and EPM	-Providing performance review capabilities -Integrating multiple data sources enterprise wide -Enabler for strategic and tactical decision making - Separation between	-Fulfilment of cross purposes with key objectives - Integration of cross-domain data sources -Identifying, monitoring and communicating key drivers of business value - Automation of higher value	-business process support by analytics for defined key performance goals - Ability to fulfil and monitor results in real-time - Infrastructure complexity that requires	- Functional and technical separation of an EPM system from analytical operational systems - Proposes technical efficiencies such as external real-time cache to avoid problems of internal

	transactional and analytical systems - Clarity on underlying technological components to have an effective implementation	processes and strategic activities - the need to couple metrics with operational data	planning in advance - Flexibility and adaptability in terms of modifying systems to suit market conditions	consistency, scalability and data latency - Discusses about improvements for operational efficiency and the challenges to anticipate - Challenges such as cost, motives, size, target, technologically upgraded to cloud and mobile

- **Support for business processes**

The EPM application integrated with RTBI has to provide business process support by providing performance review capabilities that align with the organization's objectives. The application must also provide automated execution of tasks that involves monitoring business processes for planning and enhancing new business process executions.

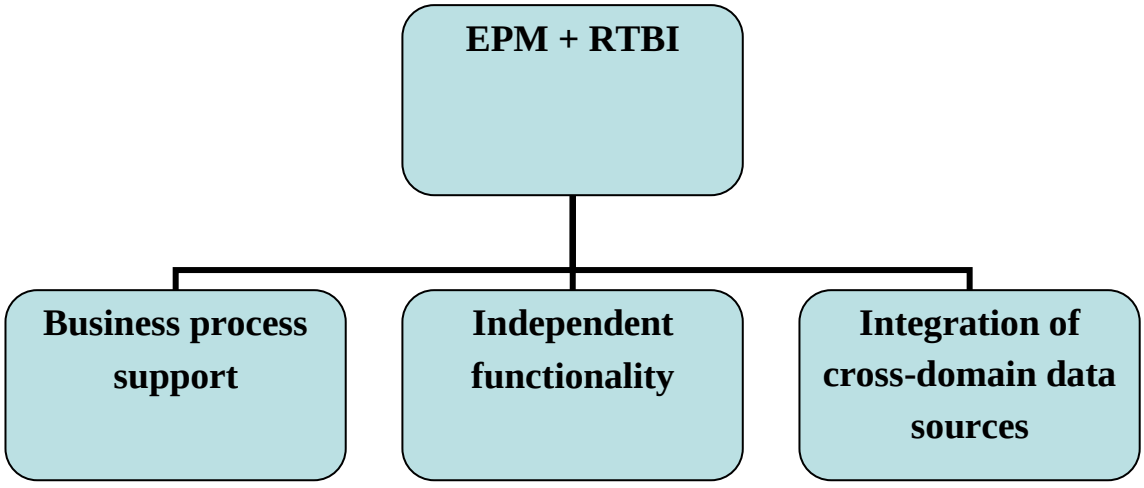


Figure 15. Criteria for combining EPM with RTBI.

- **Independent functioning of the application**

The EPM application operates itself separated from the transactional system and only links itself for data to flow back and forth. The analytical capabilities are in-built to make it a simple yet robust decision making system. The reduction in terms of load of data processing and efficiency due to fast processing is a result of the independent functioning of the system.

- **Combining data with multiple data sources**

The data provided from and to EPM applications is based on multiple data sources, thus involving extraction, transformation and load processes. The data follows a time based dimensional navigation having real-time and past historical data. The data to be integrated to an EPM application can be from cross-functional domains such as marketing, sales, CRM, ERP or other third party data warehouses. The application must provide a common platform for integrating data sources. This will enable an easy flow for import and export of data thus enabling a complete and comprehensive analysis of information.

4.3 Aligning the Framework of EPM with RTBI

As seen in *section 2.4.1,* the EPM framework consists of four phases namely;

1) Strategy
2) Planning
3) Monitoring
4) Act and Adjust

Table 11 is the synthesis matrix consisting of studies mainly (Ariyachandra & Frolick, 2008) and (Eckerson, 2003).

Table 11. Synthesis matrix (2).

Main Idea	**Source [2]**	**Source [6]**
Alignment of EPM with RTBI	- discusses on combining business strategy to technological structure to meet common goals - potential value of EPM considering the critical	-Overall impact of BI and RTBI on strategy, planning, monitoring and action stages -On strategy, key benefits of real-time collaboration, strategically enhanced decision making process

	factors of implementation - Stresses on the need for management support, sufficient resources, a project champion and management of resistance as critical success factors - Focus on contextual variables that could affect implementation success	with clear focus on aligning goals with actions -On planning, modifications of forecast and predictive results based on real-time information - Due to real-time collaboration, evidence of planning accuracy is witnessed, more efficient what-if planning scenarios - On monitoring, responsive dashboards and scorecards depicting real-time information equipped with discrepancy alarms - In the decision and action phase, timely decision making is enabled that can lead to change or retainment of set plans and strategies

The below figures (*Figures 16, 17, 18, 19*) will give a picture of the influence of RTBI on the individual components of the EPM framework and finally the impact on EPM as a whole. The results have been drawn from the studies of (Ariyachandra & Frolick, 2008), (Eckerson, 2003) and (Samsonowa, 2012) that were mainly concentrating upon the framework of EPM. (Olszak & Ziemba, 2015) discusses about the two areas of the application of a performance management namely; analytical and operational. These studies when combined produced inferences so that the elements of the framework could be aligned with the effectiveness of RTBI.

On strategic management, RTBI helps to enhance the strategic planning process due to the availability of real-time information. This helps to make last-minute strategy changes. With real-time information and updates, action can be taken to point to business strategy and identify important drivers of growth. The identification of metrics that are needed to attain strategic goals is enhanced with RTBI. *Figure 16* gives an overview of the effectiveness of RTBI on strategy.

On planning management, with the help of RTBI, plans and forecasts is enabled with real-time data and supports making changes to plans and forecasts. The strategies set in the previous step helps managers to set up plans and individual goals to attain the higher

strategic objectives. This will require each business unit to maintain an enterprise wide focus when targeting individual goals. RTBI enhances each business unit's capability to plan based on updated information in hand. *Figure 17* gives an overview of the effectiveness of RTBI on planning management.

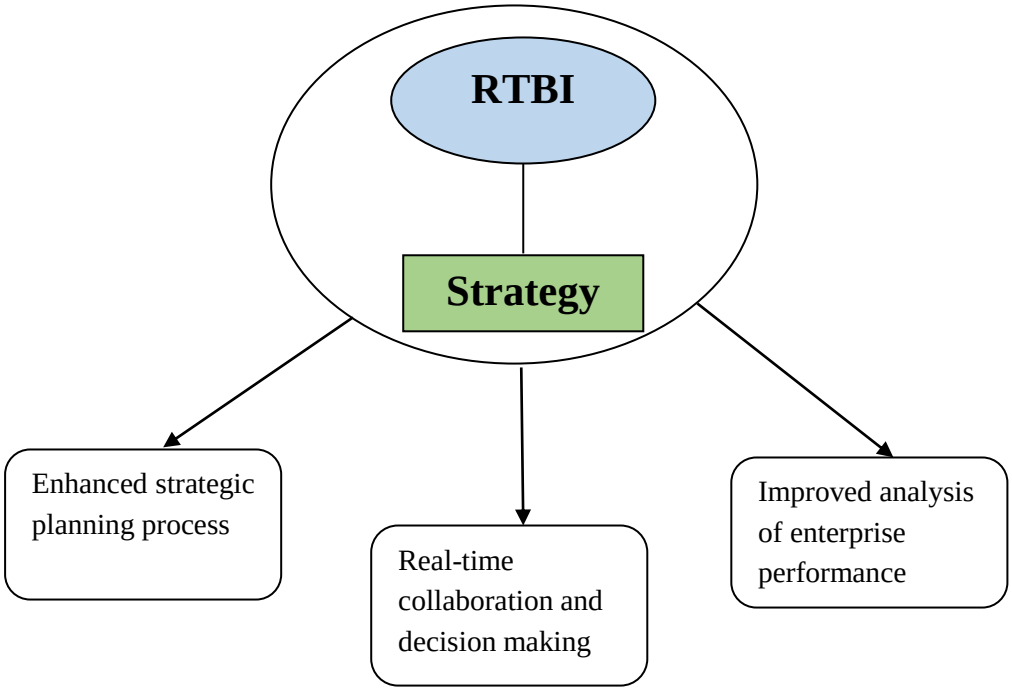


Figure 16. Influence of RTBI on Strategy Management.

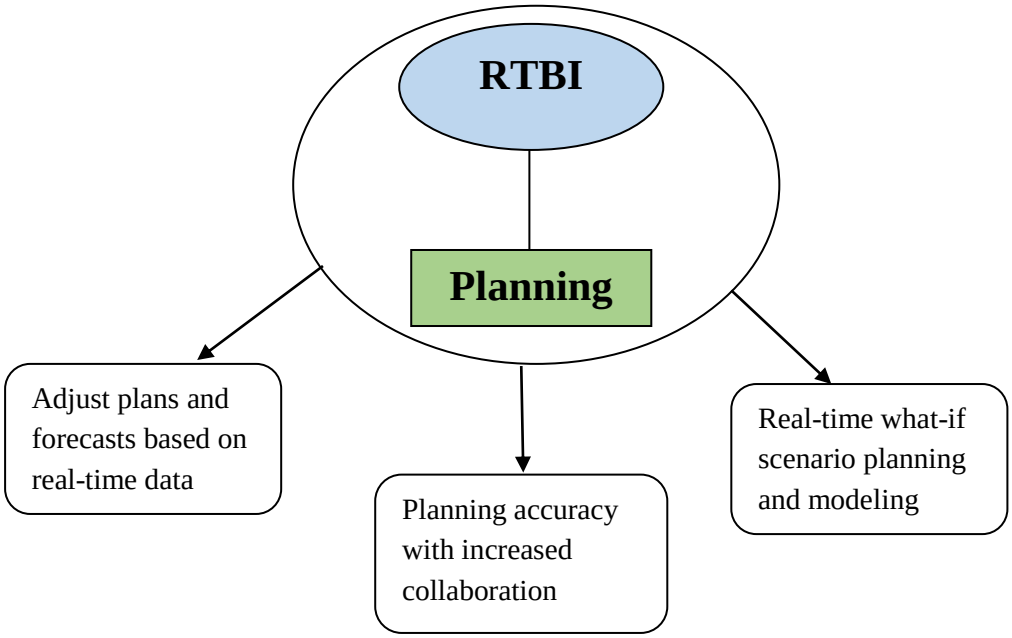


Figure 17. Influence of RTBI on Planning Management.

RTBI on the monitoring component, provides tools such as dashboards and scorecards to track performance and progress of the company compared to the strategies and plans set up in the first two phases. The ability to drill down data to the lowest granularity providing in-depth real-time detailed information is a trademark with real-time business intelligence. There is also features like an alarm to alert any discrepancy in data, so that teams can take quick action to solve problems. *Figure 18* gives an overview of the effectiveness of RTBI on monitoring stage.

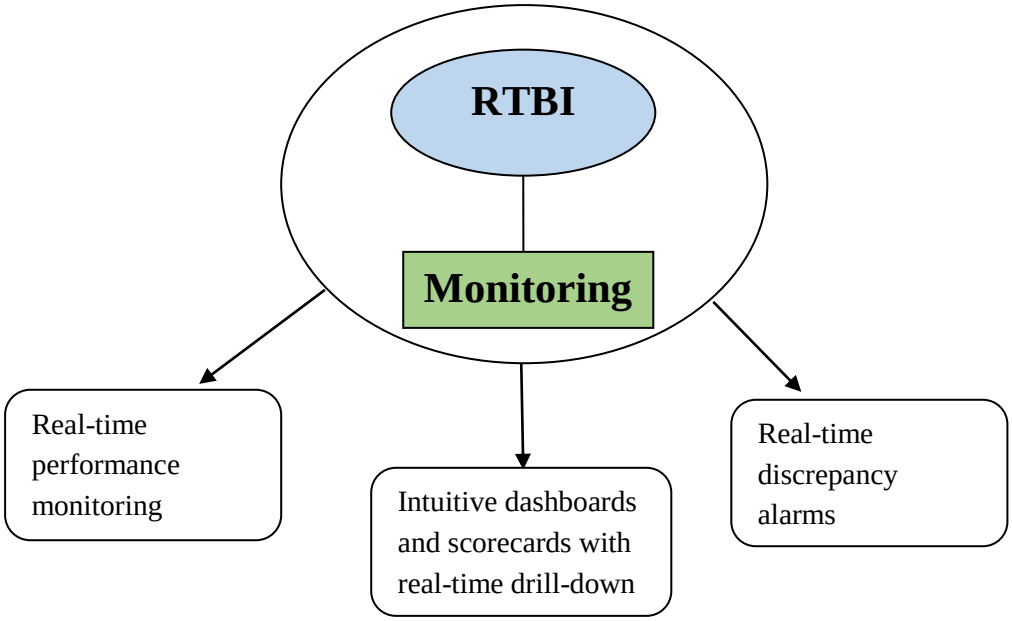


Figure 18. Influence of RTBI on Monitoring component.

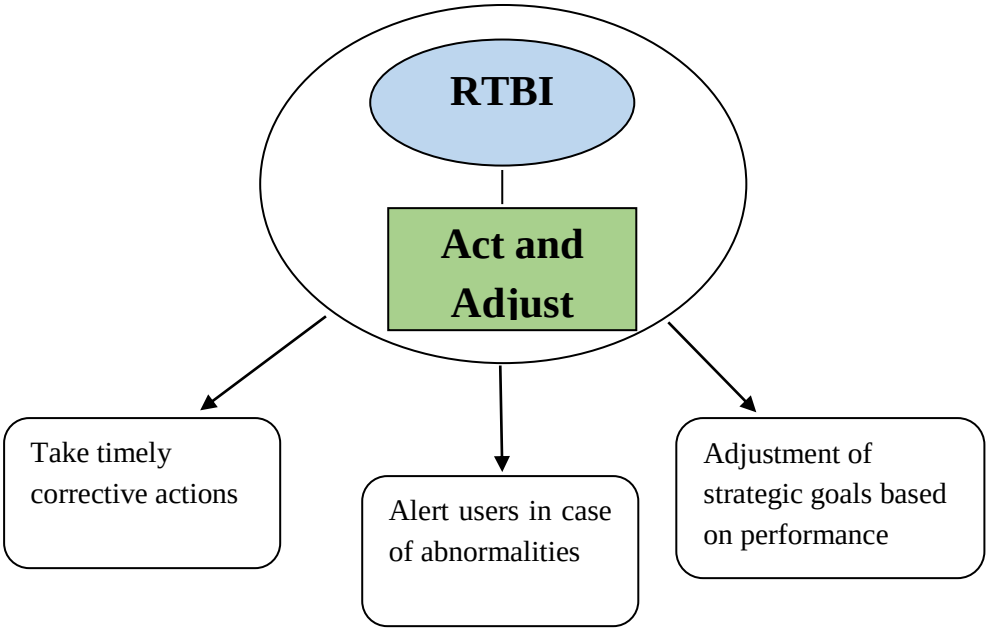


Figure 19. Influence of RTBI on Act and Adjustment component.

Finally, RTBI enhances the act and adjust component of the EPM framework by enabling users and teams to take corrective action based on analysed reports. There are features that enable EPM systems to alert users to take immediate action that can help companies prevent losses and in turn gain competitive advantage. Based on the analysis of updated reports, companies can alter strategic plans and respond to situations in a quicker manner. *Figure 19* depicts the impact of RTBI on adjustment component.

With an RTBI solution, there are benefits such as one portal for access, higher security, ad-hoc reporting and capability to make real-time decisions with up-to-date information. By having a single portal for access, there is a single version of truth with data reliability. Building strategies and planning activities like framing goals and objectives can be performed based on real-time data. Real-time data related to processes, works completed and in-progress are monitored across the organisation with built-in dashboards. Information is analysed by criteria like status of work, timelines followed, work efficiency, satisfaction from customers and causes for unexpected results. Reporting of information can be done in an ad-hoc manner suited to particular scenarios based on latest information. *Figure 20* shows the framework aligning RTBI to EPM.

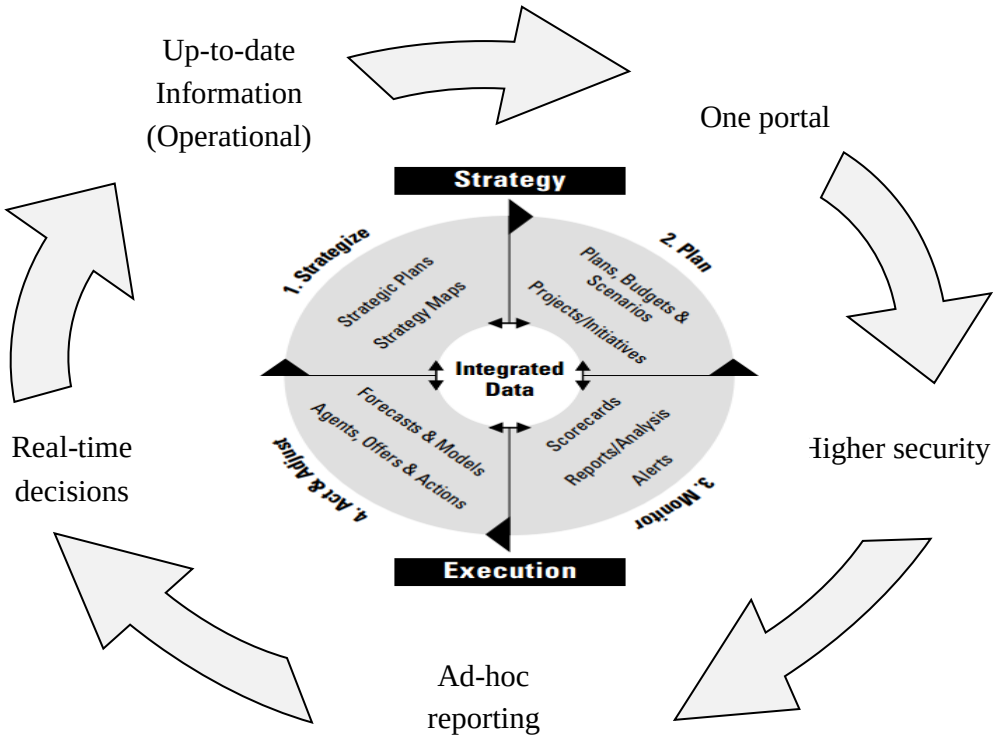


Figure 20. Framework aligning RTBI to EPM.

Finally, EPM would be about taking a holistic approach to tackle business performance. The integration of real-time business intelligence with performance management gives a sole and thorough view of the enterprise.

4.4 Challenges facing Performance Management Applications using RTBI

The adoption of a real-time business intelligence solution for enterprise performance management comes with a few challenges. Apart from the cost due to the faster processors, larger memory and other hardware involved, there are also challenges regarding handling of high volumes of data, the complexity of calculations involved, dependency on source systems, and the target to achieve zero latency. The various hurdles that could hinder an EPM with RTBI implementation were drawn from studies of (Eckerson, 2003), (Agrawal, 2008), (Azvine, Cui, & Nauck, 2005), (Hackathorn, 2004) and (Tank, 2015). Apart from the main challenges listed below, there are challenges that can be overlooked by companies initiating an EPM implementation such as selecting the appropriate and right KPIs, having an enterprise wide coordination, training users on adapting to the new solution, dealing with integration of systems and technologies. *Figure 21* gives a picture of the challenges facing an EPM implementation using RTBI. The figure arises after analyzing the synthesis matrix which consists on studies from (Agrawal, 2008), (Eckerson, 2003) and (Tank, 2015) complemented by (Azvine, Cui, & Nauck, 2005) and (Hackathorn, 2004).

Table 12. Synthesis matrix (3).

Main Idea	**Source [1]**	**Source [6]**	**Source [18]**
Challenges of EPM implementation coupled with RTBI	- Challenges regarding real-time integration of data sources - Maintaining consistency of warehouse views to receive real-time updates - Need to overcome technological challenges to enable the building of real-time systems - Source system dependency is usually high for a system that depends completely	-Organizational challenges on where to begin when EPM is focused enterprise wide - High expectation of performance improvement but not performance improvement in the right direction - Identification of key business value drivers than activity generating processes - Need the support of business from start to finish so that top-level commitment drives the	-Need to address potential challenges as part of a pre-project - Having the right software, hardware and right tools to support the whole implementation process - Support for converting data into information into action - Achievement of zero latency has always been a

	on real-time information for its processing	implementation - Decision on the size of EPM coverage in the organization defines the volume of data impacting performance drivers and complexity of calculations	challenge but target is to attain the most minimum action distance -Automation of manual processes by using intelligent technologies

- **High volume of data**

  Since a real-time business intelligence solution is based on a transactional system for retrieval of source data the volume of data to deal with is very high. Since the data retrieved is large, setting and deriving KPIs can be a tedious task.

- **Complexity of calculations**

  Since the volume of data retrieved can mostly be huge, the complexity of calculation rises proportionally along with time. The volume, variety of difference source formats can lead to time consuming calculations.

- **Source system dependency**

  The source system performance is crucial to decide the performance of the performance management application and RTBI solution. If the transactional source systems such as HCM, ERP, GLs, CRM or SCM is slow or malfunctions then the applications based on it will also undergo delay in retrieval of data. The need is to not degrade the working performance of the source systems' running of processes and jobs. The recovery time can be high and delayed in case of a server or source system issue in this scenario.

- **Achieving zero latency**

  Real-time business intelligence can never actually fetch and process data in real-time. There is always a latency between data retrieval, analysis and to the point where reporting is done. The term that could be used is near-real time. This has often been a topic for research and debate. The distance between near-real time and real-time can be reduced based on the volume of data and technology being used.

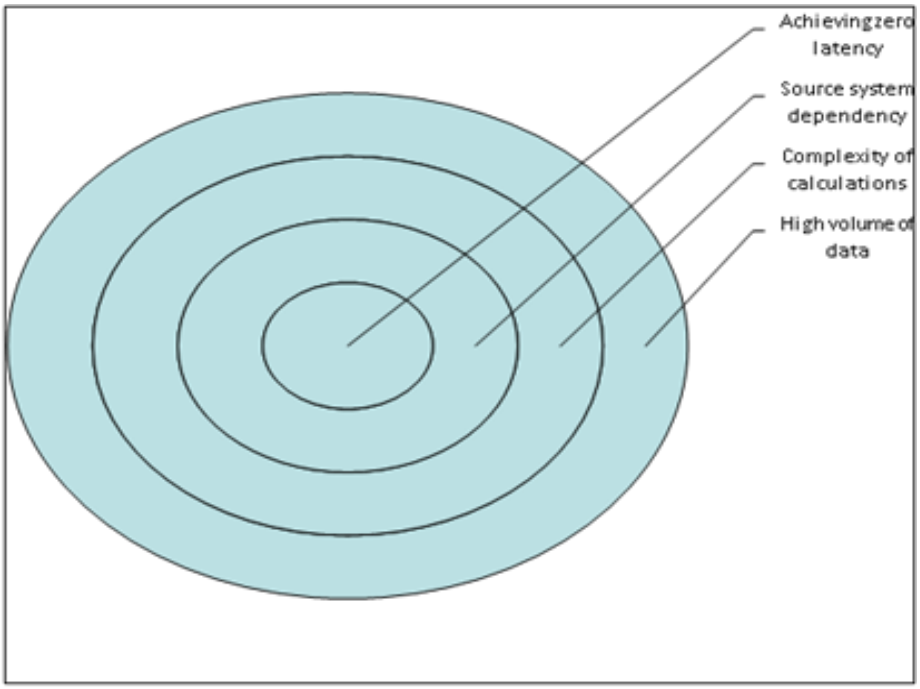


Figure 21. Challenges of EPM applications using RTBI.

Before deploying an enterprise performance management coupled with real-time business intelligence technology, a firm needs to answer to the questions listed in *Table 13.* The table gives the list of some of the most important questions the enterprise needs to answer to, before deciding on implementing a performance management software enabled by real-time business intelligence. These questions were primarily framed after reading in detail all the 18 primary studies selected with more inclination towards *section 4.4.*

Table 13. Questions to be considered before implementation of EPM powered by RTBI.

Count	**Question**
1.	Which areas of the company requires performance management software? For example; only finance or across the whole business?
2.	Does your company possess a short-term and long-term strategy and vision?
3.	Is real-time information required to assess business performance? In other words, how critical are your business operations?

4.	Which information is needed to support business metrics?
5.	If the implementation is proven to be successful, how much is your success worth?
6.	Does the company have the technically and functionally equipped professional resources to implement the solution?
7.	Are mobile and cloud-based solutions part of the bigger strategy?
8.	Is the vendor chosen keeping in mind their reputation and support for further growth and support for your company?
9.	How large is your enterprise in terms of revenue? Are certain processes more critical than others?

5. CONCLUSION

5.1 Research Results Meeting its Objectives

The research study focused on the research question (chapter 1.4) "*What is the effectiveness of real-time business intelligence on enterprise performance management? How does real-time BI work together with EPM?*" This study has enabled producing results and answers to this specific research question.

Enterprise performance management is a broad term but this study has drilled it down to a four component framework consisting of strategy, planning, monitoring and, act and adjust. In each of the levels, the impact of real-time business intelligence is high. The main effective features highlighted are the availability of a single portal of access, higher security due to an embedded framework, ad-hoc on-demand reporting due to the availability of real-time information, and an enabler for real-time decision making. The research which started with the collection of relevant studies was further drilled down to the most helpful studies.

Even though finding articles that was exactly matching the question was difficult, synthesizing evidences from a variety of topics that support the research question made this entire systematic literature review a successful endeavor. There has been a clear advantage of combining real-time business intelligence with EPM compared to the few challenges of its implementation. EPM has been turned into a real-time decision making system with RTBI technology, compared to its traditional use of just a performance measurement and management system.

Followed by the results are the findings of the systematic review. The findings are assessed and published based on the important results of this study. The importance of undertaking a research to first analyze the need for an RTBI powered EPM system has been the utmost priority before delving into its implementation.

5.2 Findings of the Systematic Review

The focus of this systematic literature review thesis was to study the effectiveness of real-time business intelligence solutions on performance management of an enterprise. It was also intended to study the linkage and the challenges that could hinder this combinational process as mentioned in the introductory *chapter 1*.

The main benefits of having the performance management solution powered by real-time business intelligence is having timely data thus enabling faster decision making, reducing costs, providing greater customer satisfaction amongst many others. The focus would be to possess operational intelligence and real-time decision making by having a setting of automated processes to analyze large amounts of data. This would eliminate the need to monitor dashboards. The close integration between operational and analytical systems has enabled performance systems to operate in a more efficient way.

Enterprise performance management powered by real-time business intelligence is at an all-time focus for the organizations looking to compete. The business cycles are happening at rapid speed together with planning, budgeting, and forecasting. The vast amount of data available along with the need for more accountability has increased the scope for implementing an EPM solution. A real-time business intelligence solution is effective in answering fundamental questions of a business and when combined with statement of management goals, it enables EPM processes to be implemented efficiently considering many background elements.

It is evident that EPM powered by real-time business intelligence is an advantageous combination adding considerable value with challenges involved as explained in *section 4.4*. Real-time business intelligence provides advanced analytics to gain insights into business operations. The enablement to connect to disparate data sources in real-time and to perform real-time planning and analysis using personalized dashboards and KPIs gives a business competitive advantage to succeed. In the end, it comes down to the respective organization to decide if real-time data is required to power their performance management solution based on their level of accepting latency data.

The following inferred points describe the ways organisations can leverage the benefits of RTBI on EPM.

Signs of competitive advantage

- The role played by real-time business intelligence has changed the shape of an EPM solution. The side of decision support has been changed by making it possible to affect current decision making and business processes.

- Real-time business intelligence adds more depth and insight to EPM. Advanced analytics with predictive capabilities that use advanced algorithms, machine learning provide advanced forecasting and analysis for performance management.

- By harnessing real-time business intelligence capabilities, EPM solutions can provide scorecards and dashboards that are aimed to track progress to create and execute business initiatives such as market development and marketing campaigns.

- Real-time integration is required to enable automatic data flow for EPM processes such as timely financial close and consolidation, budget planning, forecasting and management reporting. However, if financial reporting is periodic, there may not be a need for real-time integration.

- Key performance indicators (KPIs), linked to cause and effect are to be more widely accepted across the organization to have each individual's actions aligned with the long term strategy of the business.

- Financial reports can be made in real-time or near real-time with EPM powered by real-time business intelligence which leads to gaining higher competitive advantage.

- Real-time business intelligence powering an EPM solution is seen as a major tool enabling organisations to produce reports, plan and predict past, present and future states.

- Identifying trends, calculating relationships, performing ratio calculations and analysing differences and abnormalities with real-time information helps companies build heavy competitive advantage.

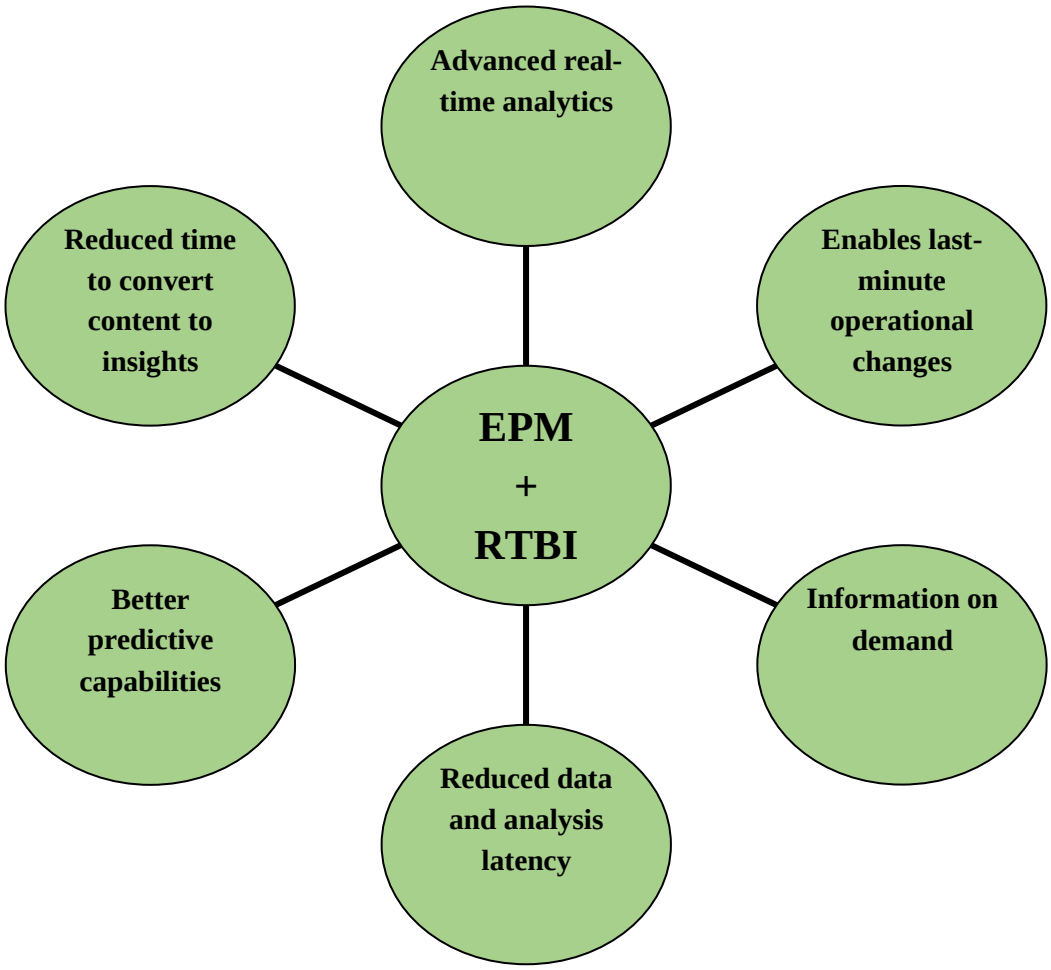


Figure 22. Signs of competitive advantage for EPM +RTBI.

Issues to consider

- The effectiveness of real-time business intelligence on enterprise performance management can be impeded if transaction systems are loosely coupled with performance management platforms.

- Factors such as budget, costs involved, size of enterprise, criticality of business processes, availability of functional and technical resources, achieving a long term and short term vision for aligning goals with strategy

- When it comes to selection criteria for an EPM solution software, functional capabilities and reporting are high priorities along with modelling and analytical activities.

- Latency between the transaction ERP system and an EPM's analytical system has been a hindrance to high performance. However, hybrid transactional-analytical platforms that can take care of both transactional and advanced analytics has proven to be a huge boost.

In conclusion it is clear from the primary studies chosen, that more research work has to be done to explore deeper into the effectiveness of real-time business intelligence on enterprise performance management in terms of understanding the whole ecosystem of implementation, and the effects of it. While most of the articles in the research agree to the benefits of EPM with RTBI, there are other articles that construct an effective realization of the issues an organization can be faced with before and after the implementation. While *figure 22* shows signs of competitive advantage, *section 4.4* and *table 13* helps to ponder about the ramifications and consequences of this implementation. One of the key issues discussed revolves around reducing the three latencies; data latency, analysis latency and decision/action latency, Data and analysis latency are reduced significantly with today's advanced technologies. However, decision/action latency reduction is still a topic left open for research. This leads to the topic of future research *(section 5.3)* in the field of artificial intelligence wherein automated decision making is enabled by cognitive science.

On a larger note, this study states that the effectiveness of RTBI on EPM is hugely beneficial providing companies a chance to gain competitive advantage mainly due to the availability of real-time information and managing performance using it but not before assessing the conditions and reasons for implementation.

5.3 Future Work

Even though the benefits of real-time business intelligence has shown to carry business value, in the research field there is still scope for providing a foundation with regard to

methodologies and theories. The number of studies and research involving the effectiveness of real-time business intelligence on performance management systems is still few. There is an opportunity to collaborate with vendors providing this solution to understand further on this topic. There also needs to be mutual understanding on what real-time information actually means. Terms such as real-time, near real-time and right time are making rounds and it would be beneficial for researchers and others concerned to fix the term and definition, so that customers can request what they exactly need. *Figure 23* gives the overall futuristic research topics that can be undertaken relevant to his field.

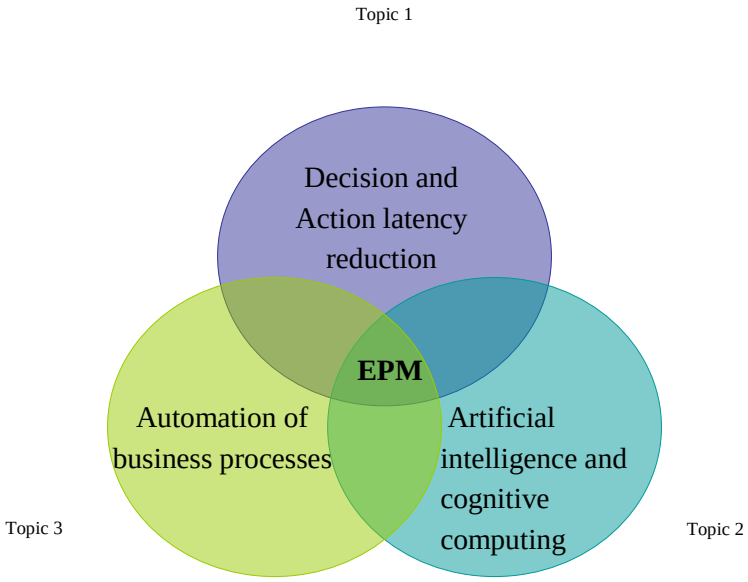


Figure 23. Topics for future research regarding EPM.

With real-time business intelligence, performance management systems have instant or near real-time information to plan, forecast, report and predict outcomes. The issue of data and analysis latency is almost close to zero, however, decision and action latency needs more investigation and research can be undertaken to check if process execution can be automated. Organizations are increasingly using the cloud for EPM to attain capabilities such as faster time to value, better interfaces, no upgrades, new functionalities and advanced analytics enabled by real-time business intelligence.

Another future research recommendation would be to study on the effectiveness of common notation standards in reporting standards so that information is understood faster and better. At least on an organizational level if reporting standards using common notation is followed, this would enable information to be processed faster. Automated data monitoring could be completely enabled when rules are followed in reporting standards. When there is a need for human intervention, the handover time must be minimal to make the entire process of performance management efficient.

Artificial intelligence and cognitive computing could play major roles helping performance management professionals in decision making activities by providing suggestions that are not evident to human perception.

In order to discover new problems and research fields, systematic literature reviews should not limit itself to a one step process rather an ongoing process (Albanese *et al.* 2002).

REFERENCES

Azvine, B., Cui, Z., & Nauck, D. D. (2005). Towards real-time business intelligence. *BT Technology Journal*, *23*(3), 214–225. Retrieved from http://link.springer.com/article/10.1007/s10550-005-0043-0

Azvine, B., Cui, Z., & Nauck, D. D. (2005). Towards real-time business intelligence. *BT Technology Journal*, *23*(3), 214–225.

Bose, R. (2006). Understanding management data systems for enterprise performance management. *Industrial Management & Data Systems*, *106*(1), 43–59. https://doi.org/10.1108/02635570610640988

Davis, J. R. (2006). Right-Time Business Intelligence: Optimizing the Business Decision Cycle. *B-EYE-Network. Com*. Retrieved from https://pdfs.semanticscholar.org/f621/1a5a8ff4723b83eba256b462f7fd3f10c95e.pdf

Eckerson, W. (2003). Building the real-time enterprise. *TDWI Report Series*, 1–35.

Hackathorn, R. (2002). Current practices in active data warehousing. *Bolder Technology*. Retrieved from http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.539.8508&rep=rep1&type=pdf

Hackathorn, R. (2004). Real-time to real-value. Information Management, 14(1), 24. Retrieved from http://search.proquest.com/openview/6933f9aae5d480c5cc1c4a444b9ec55b/1?pq-origsite=gscholar&cbl=51938.

Hou, C.-K. (2012). Examining the effect of user satisfaction on system usage and individual performance with business intelligence systems: An empirical study of Taiwan's electronics industry. *International Journal of Information Management, 32*(6), 560–573. https://doi.org/10.1016/j.ijinfomgt.2012.03.001

Kitchenham, B., & Charters, S. (2007). Guidelines for performing systematic literature reviews in software engineering. In *Technical report, Ver. 2.3 EBSE Technical Report. EBSE*. Retrieved from http://www.academia.edu/download/35830450/2_143465389588742151.pdf

Limburg, D. (2010). The Impact of Enterprise Performance Management on Management Control. In *UK Academy for Information Systems Conference Proceedings*. Retrieved from http://aisel.aisnet.org/cgi/viewcontent.cgi?article=1031&context=ukais2010

Melchert, F., Winter, R., & Klesse, M. (2004). Aligning process automation and business intelligence to support corporate performance management. *AMCIS 2004 Proceedings*, 507.

Mikroyannidis, A., & Theodoulidis, B. (2010). Ontology management and evolution for business intelligence. *International Journal of Information Management, 30*(6), 559–566. https://doi.org/10.1016/j.ijinfomgt.2009.10.002

Olszak, C. M., & Ziemba, E. (2015). Business performance management for competitive advantage in the information economy. *The Journal of Internet Banking and Commerce, 2010*. Retrieved from http://www.icommercecentral.com/open-access/business-performance-management-for-competitive-advantage-in-the-information-economy.php?aid=38448

Peters, M. D., Wieder, B., Sutton, S. G., & Wakefield, J. (2016). Business intelligence systems use in performance measurement capabilities: Implications for enhanced competitive advantage. *International Journal of Accounting Information Systems*, *21*, 1–17. https://doi.org/10.1016/j.accinf.2016.03.001

Popeangă, J. (2012). Real-Time Business Intelligence for the Utilities Industry. *Database Systems Journal*, *3*(4), 15–24.

Ranjan, J. (2008). Real time business intelligence in supply chain analytics. *Information Management & Computer Security*, *16*(1), 28–48. https://doi.org/10.1108/09685220810862733

Rouhani, S., Ashrafi, A., Zare Ravasan, A., & Afshari, S. (2016). The impact model of business intelligence on decision support and organizational benefits. *Journal of Enterprise Information Management*, *29*(1), 19–50. https://doi.org/10.1108/JEIM-12-2014-0126

Sahay, B. S., & Ranjan, J. (2008). Real time business intelligence in supply chain analytics. *Information Management & Computer Security*, *16*(1), 28–48. https://doi.org/10.1108/09685220810862733

Samsonowa, T. (2012). Performance Management. In T. Samsonowa, *Industrial Research Performance Management* (pp. 9–52). Heidelberg: Physica-Verlag HD. https://doi.org/10.1007/978-3-7908-2762-0_2

Seufert, A., & Schiefer, J. (2005). Enhanced business intelligence - supporting business processes with real-time business analytics. In *16th International Workshop on Database and Expert Systems Applications (DEXA'05)* (pp. 919–925). https://doi.org/10.1109/DEXA.2005.86

Sharman, P. (2016). Creating value with CPM: corporate performance management software can help financial professionals make better decisions. *Strategic Finance, 97*(9), 53–62.

Tvrdikova, M. (2007). Support of Decision Making by Business Intelligence Tools. In *6th International Conference on Computer Information Systems and Industrial Management Applications, 2007. CISIM '07* (pp. 364–368). https://doi.org/10.1109/CISIM.2007.64

Wade, D., & Recardo, R. J. (2001). *Corporate performance management: how to build a better organization through measurement-driven strategic alignment*.

Sharp, J. A. and Howard, K. (1996) "The management of a student research project", 2nd Edition, Gower, Aldershot.

Singh, H., Motwani, J. and Kumar, A. (2000), "A review and analysis of the state-of-the-art research on productivity measurement", Industrial Management & Data Systems, Vol. 100 No. 5, pp. 234-41.

Thomsen, E. (1997), OLAP Solutions: Building Multidimensional Information Systems, Wiley, New York, NY.

Toni, A.D., Nassimbeni, G. and Tonchia, S. (1997), "An integrated production performance measurement system", Industrial Management & Data Systems, Vol. 97 No. 5, pp. 180-6.

Walker, K. B. (1996). Corporate performance reporting revisited - the balanced scorecard and dynamic management reporting. Industrial Management & Data Systems, 96(3), 24–30. https://doi.org/10.1108/02635579610114929

APPENDIX

Appendix A:

A.1 Study Quality Assessment

According to (Kitchenham & Charters, 2007), the study quality could be assessed by answering the following questions. The questions have been answered in relation to this thesis study.

1) **Do the research method(s) follow the questions asked in the study?**
   All primary studies possessed an appropriate research method and logically followed the questions asked in the study. The studies addressed the question of effectiveness of real-time business intelligence on performance management.

2) **How credible are the findings?**
   The primary studies retrieved were quite credible since they were found in established databases from authors of proven knowledge in the chosen field.

3) **Is the study design appropriate and does it logically follow the question asked in the primary study?**
   All the primary studies that were included as part of the systematic literature review had an appropriate study design and followed the main research questions being asked.

4) **How has knowledge or understanding been extended by the research?**
   The research from the primary studies were able to explore individual topics deeper and provide reasonable findings for more research.

5) **How well was data collection carried out?**
   The data collection had a systematic approach in all primary studies that were selected. Some studies were experiments, some were case studies, and few literature reviews. Each study had its own method of data collection but they followed a logical pattern.

6) **How well has diversity of perspective and context been explored?**
   The primary studies explored the topics in detail and with the many references of articles in each primary study, the diversity factor (e.g. geographical location) was well addressed.

7) **How clear are the links between data, interpretation and conclusions – i.e. how well can the route to any conclusions be seen?**

The data, interpretation and conclusions were clear in all of the primary studies selected. The studies selected were organized in their structure making it easier to find the linkage between data, interpretation from the data and finally evidence based conclusions.

8) **How clear and coherent is the reporting?**

The reporting from all the primary studies was clear and coherent making the articles easy to read and understand. However, few primary studies did not report at an adequate level compared to the rest of the studies.

9) **Were different sources of knowledge explored about the issues being compared?**

The study was conducted after consulting different sources of knowledge at an adequate level. The primary studies included a wide list of references thus expanding the knowledge to a large number of sources.

Appendix B:

PRIMARY STUDIES INCLUDED IN SYSTEMATIC REVIEW

[1] Agrawal, D. (2008). The reality of real-time business intelligence. In *International Workshop on Business Intelligence for the Real-Time Enterprise* (pp. 75–88). Springer. Retrieved from http://link.springer.com/10.1007/978-3-642-03422-0_6

[2] Ariyachandra, T. R., & Frolick, M. N. (2008). Critical Success Factors in Business Performance Management—Striving for Success. *Information Systems Management*, *25*(2), 113–120. https://doi.org/10.1080/10580530801941504

[3] Bogdana, P. I., Felicia, A., Delia, B., & others. (2009). The role of business intelligence in business performance management. *Annals of Faculty of Economics*, *4*(1), 1025–1029. Retrieved from http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.461.5849&rep=rep1&type=pdf

[4] Ballard, C., McDonald, S., Goerlich, O., White, C., Myllymaki, J., & Neroda, A. (2005). *Business Performance Management: Meets Business Intelligence. IBM.*

[5] Bose, R. (2006). Understanding management data systems for enterprise performance management. *Industrial Management & Data Systems*, *106*(1), 43–59. https://doi.org/10.1108/02635570610640988

[6] Eckerson, W. (2003). Building the real-time enterprise. *TDWI Report Series*, 1–35.

[7] Hartl, K., Jacob, O., Mbep, F. L., Budree, A., & Fourie, L. (2016). The Impact of Business Intelligence on Corporate Performance Management. In *2016 49th Hawaii International Conference on System Sciences (HICSS)* (pp. 5042–5051).

[8] Hribar Rajterič, I. (2010). Overview of business intelligence maturity models. *Management: Journal of Contemporary Management Issues*, *15*(1), 47–67.

[9] Larson, D., & Chang, V. (2016). A review and future direction of agile, business intelligence, analytics and data science. *International Journal of Information Management*, *36*(5), 700–710. https://doi.org/10.1016/j.ijinfomgt.2016.04.013

[10] Olszak, C. M., & Ziemba, E. (2015). Business performance management for competitive advantage in the information economy. The Journal of Internet Banking and Commerce, 2010. Retrieved from http://www.icommercecentral.com/open-access/business-performance-management-for-competitive-advantage-in-the-information-economy.php?aid=38448

[11] Panian, Z. (2009). Just-in-time business intelligence and real-time decisioning. *Recent Advances in Applied Informatics and Communications, Proceedings of AIC*, *9*, 106–111. Retrieved from http://universitypress.org.uk/journals/ami/ami-5.pdf

[12] Peters, M. D., Wieder, B., Sutton, S. G., & Wakefield, J. (2016). Business intelligence systems use in performance measurement capabilities: Implications for enhanced competitive advantage. *International Journal of Accounting Information Systems*, *21*, 1–17.

[13] Popeangă, J. (2012). Real-Time Business Intelligence for the Utilities Industry. *Database Systems Journal*, *3*(4), 15–24. Retrieved from http://dbjournal.ro/archive/10/10.pdf#page=15

[14] Rouhani, S., Ashrafi, A., Zare Ravasan, A., & Afshari, S. (2016). The impact model of business intelligence on decision support and organizational benefits. *Journal of Enterprise Information Management*, *29*(1), 19–50. Retrieved from http://www.emeraldinsight.com/doi/10.1108/JEIM-12-2014-0126

[15] Sandu, D. (2008). Operational and real-time business intelligence. *Revista Informatica Economică*, *3*(47), 33–36. Retrieved from http://www.revistaie.ase.ro/content/47/06Sandu.pdf

[16] Sharman, P. (2016). Creating value with CPM: corporate performance management software can help financial professionals make better decisions. *Strategic Finance*, *97*(9), 53–62. Retrieved from http://go.galegroup.com/ps/i.do?id=GALE%7CA447881714&sid=googleScholar&v=2.1&it=r&linkaccess=fulltext&issn=1524833X&p=AONE&sw=w

[17] Shi, Y., & Lu, X. (2010). The Role of Business Intelligence in Business Performance Management. In *2010 3rd International Conference on Information Management, Innovation Management and Industrial Engineering* (Vol. 4, pp. 184–186). https://doi.org/10.1109/ICIII.2010.522

[18] Tank, D. (2015). Enable Better and Timelier Decision-Making Using Real-Time Business Intelligence System. *International Journal of Information Engineering and Electronic Business*, *7*(1), 43–48. https://doi.org/10.5815/ijieeb.2015.01.06

Data Synthesis of Primary Studies

Table 1. Characteristics of Primary Studies.

Primary studies	Research Methodology	System Type	Study setting
[1]	Case Study	Academic	Academia
[2]	Case Study	Academic	Academia
[3]	Observational	Academia	Academia
[4]	Survey + Case Study	Industry	Academia + Industry
[5]	Case Study	Academic + Industry	Academia + Industry
[6]	Case Study	Academic	Academia
[7]	Case Study + Survey	Academic	Academia
[8]	Observational	Academic	Academia
[9]	Case Study	Academic	Academia

[10]	Observational + Survey	Industry	Academia + Industry
[11]	Survey + Case Study	Academic	Academia + Industry
[12]	Case Study+ Observational	Academic	Academia + Industry
[13]	Case Study	Academic	Academia
[14]	Case Study+ Survey+ Observational	Academic	Academia + Industry
[15]	Case Study	Academic	Academia
[16]	Case Study	Industry	Industry
[17]	Observational	Academia	Academia
[18]	Case Study	Academic	Academia

Table 2. Study Design of Primary Studies.

Primary studies	**Study Design**	**Context Sensitivity of Study Design**	**Data Collection Approach**	**Level of Different Sources Utilized**	**Level of Original Evidence Given**
[1]	Appropriate	Appropriate	Appropriate	Satisfactory	Adequate
[2]	Appropriate	No information	Appropriate	Satisfactory	Adequate
[3]	Appropriate	Appropriate	Appropriate	Satisfactory	Adequate
[4]	Appropriate	No information	Appropriate	Satisfactory	Adequate
[5]	Appropriate	Appropriate	Appropriate	Satisfactory	Adequate
[6]	Appropriate	Appropriate	Appropriate	Satisfactory	Adequate
[7]	Appropriate	Appropriate	Appropriate	Satisfactory	Adequate
[8]	Appropriate	No information	Appropriate	Satisfactory	Adequate

[9]	Appropriate	Appropriate	Appropriate	Satisfactory	Adequate
[10]	Appropriate	No information	Appropriate	Satisfactory	Adequate
[11]	Appropriate	Appropriate	Appropriate	Satisfactory	Adequate
[12]	Appropriate	Appropriate	Appropriate	Satisfactory	Adequate
[13]	Appropriate	Appropriate	Appropriate	Satisfactory	Adequate
[14]	Appropriate	No information	Appropriate	Satisfactory	Adequate
[15]	Appropriate	Appropriate	Appropriate	Satisfactory	Adequate
[16]	Appropriate	No information	Appropriate	Satisfactory	Adequate
[17]	Appropriate	Appropriate	Appropriate	Satisfactory	Adequate
[18]	Appropriate	Appropriate	Appropriate	Satisfactory	Adequate

STUDIES EXCLUDED FROM SYSTEMATIC REVIEW

[1] Al-Aqrabi, H., Liu, L., Hill, R., & Antonopoulos, N. (2015). Cloud BI: Future of business intelligence in the Cloud. *Journal of Computer and System Sciences*, *81*(1), 85–96. https://doi.org/10.1016/j.jcss.2014.06.013

[2] Bourne, M., Franco, M., & Wilkes, J. (2003). Corporate performance management. *Measuring Business Excellence*, *7*(3), 15–21. https://doi.org/10.1108/13683040310496462

[3] Cao, G., Duan, Y., Cadden, T., & Minocha, S. (2016). Systemic capabilities: the source of IT business value. *Information Technology & People*, *29*(3), 556–579. https://doi.org/10.1108/ITP-05-2014-0090

[4] Chang, V. (2014). The Business Intelligence as a Service in the Cloud. *Future Generation Computer Systems*, *37*, 512–534. https://doi.org/10.1016/j.future.2013.12.028

[5] Chen, H., Chiang, R. H., & Storey, V. C. (2012). Business intelligence and analytics: From big data to big impact. MIS Quarterly, 36(4), 1165–1188. http://www.academia.edu/download/32970305/FROM_BIG_DATA_TO_BIG_IMPACT.pdf

[6] De Toni, A., Nassimbeni, G., & Tonchia, S. (1997). An integrated production performance measurement system. *Industrial Management & Data Systems*, *97*(5), 180–186. https://doi.org/10.1108/02635579710169559

[7] Herschel, R. T., & Jones, N. E. (2005). Knowledge management and business intelligence: the importance of integration. *Journal of Knowledge Management*, *9*(4), 45–55. https://doi.org/10.1108/13673270510610323

[8] Işık, Ö. Jones, M. C., & Sidorova, A. (2013). Business intelligence success: The roles of BI capabilities and decision environments. *Information & Management*, *50*(1), 13–23. https://doi.org/10.1016/j.im.2012.12.001

[9] Malhotra, Y. (2005). Integrating knowledge management technologies in organizational business processes: getting real time enterprises to deliver real business performance. *Journal of Knowledge Management*, *9*(1), 7–28. https://doi.org/10.1108/13673270510582938

[10] Ortiz, S. (2002). Is business intelligence a smart move? *Computer*, *35*(7), 11–14. https://doi.org/10.1109/MC.2002.1016894

[11] Pun, K. F., & White, A. S. (2005). A performance measurement paradigm for integrating strategy formulation: A review of systems and frameworks. *International*

Journal of Management Reviews, 7(1), 49–71. https://doi.org/10.1111/j.1468-2370.2005.00106.x

[12] Ranjan, J. (2008). Business justification with business intelligence. *VINE, 38*(4), 461–475. https://doi.org/10.1108/03055720810917714

[13] Russom, P. (2013). Operational intelligence: real-time business analytics from big data. *TDWI Checkl. Rep*, 1–8. Retrieved from http://download.101com.com/pub/tdwi/files/vitria081412.pdf

[14] Schläfke, M., Silvi, R., & Möller, K. (2012). A framework for business analytics in performance management. *International Journal of Productivity and Performance Management, 62*(1), 110–122. https://doi.org/10.1108/17410401311285327

[15] Suwignjo, P., Bititci, U. S., & Carrie, A. S. (2000). Quantitative models for performance measurement system. *International Journal of Production Economics, 64*(1), 231–241. Retrieved from http://www.sciencedirect.com/science/article/pii/S0925527399000614

[16] Williams, S., Williams, N. (2003). The business value of business intelligence. *Business Intelligence Journal, 8,* 30–39. Retrieved from https://pdfs.semanticscholar.org/b491/525cee35985b3c13abca8e7df6b56c00ac7b.pdf

[17] Yigitbasioglu, O. M., & Velcu-Laitinen, O. (2012). The Use of Dashboards in Performance Management: Evidence from Sales Managers. *The International Journal of Digital Accounting Research, 12*, 36–58. https://doi.org/10.4192/1577-8517-v12_2

Table 3. *Reason for exclusion of evaluated studies.*

Excluded primary studies	**Reason for exclusion**
[1]	Body text deviation from topic
[2]	Repetition of information from already selected primary study
[3]	Inappropriate study analysis

[4]	Disconnected study design
[5]	Repetition of information
[6]	Deviation from research topic
[7]	Repetition of information and inappropriate study design
[8]	Deviation of body text
[9]	Partly relatable but presence of repetition.
[10]	Insufficient evidence of data collection
[11]	Deviation of body text
[12]	Repetition of information
[13]	Body text deviation from topic
[14]	Relatable evidence but lack of evidence and incomplete information
[15]	Deviation of body text and lack of theoretical information
[16]	Repetition of information and slight irrelevance to topic.
[17]	Incomplete information